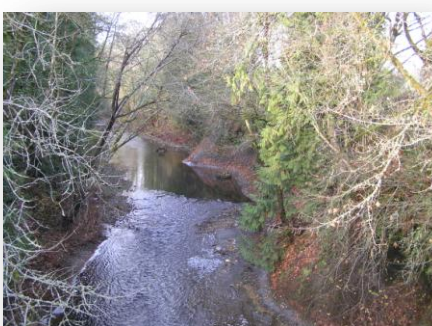
Watershed Characterization and Analysis of South Lewis County

Lower Cowlitz River Watershed

March 23, 2009
Final Draft



Department of Ecology
Shorelands & Environmental Assistance Program

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Introduction

Background

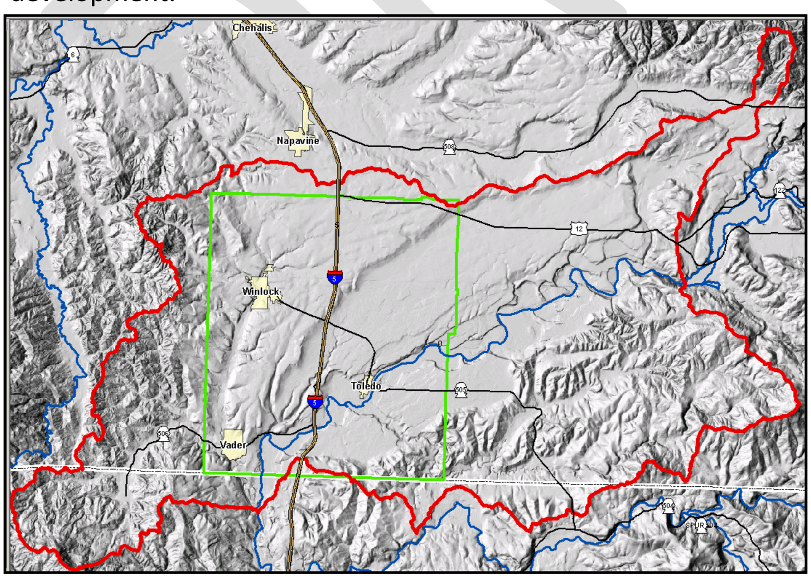
In spring 2008 the Washington State Legislature provided funding to Lewis County, the Department of Ecology, and the Department of Fish and Wildlife to assist in a watershed based subarea plan for the watersheds surrounding the towns of Toledo, Winlock, and Vader. The study area is depicted in Figure 1. The primary objectives of this watershed-based mitigation program are to:

(1) provide better long-term protection of watershed processes and functions
(2) identify the best areas for protection, restoration, and development
(3) create an economic development strategy for the South County (Toledo, Winlock & Vader)

This South County Subarea Plan will be based on a characterization of watershed hydrologic processes, a landscape habitat assessment, an economic forecast, land use assumptions, and input from a broad-based local stakeholders group. The purpose of this document is to present the preliminary results of the characterization of watershed processes for the study area. The plan will be revised in the spring of 2009 in order to incorporate the results of the WDFW local habitat characterization and input from the county and stakeholders.

Approach

Characterizing watershed processes within the study area is central to developing a successful watershed-based subarea plan. An adequate characterization will provide local jurisdictions with information on the best areas for mitigation, protection of watershed processes, and development.



For example, watershed characterization and analysis helps to identify areas that are important for maintaining watershed processes (Figure 2) as well as how much these areas have been impaired (Appendix Figures C-3,C-4, C-5).

Figure 1. Study Area for South Lewis County (green box) with watershed boundary for study area (red outline).

The central assumption to this characterization approach is that the health of aquatic resources is dependent upon intact, up gradient watershed processes. Research has demonstrated that we must consider the watershed processes that occur outside of aquatic ecosystems if we are to protect and restore our lakes, rivers, wetlands, and estuaries (National Research Council 2001, Dale et al. 2000, Bedford and Preston 1988, Roni et al. 2002, Poiani et al. 1996, Gersib 2001, Gove et al. 2001).

Watershed Processes: In this document, *watershed processes* refers to the dynamic physical and chemical interactions that form and maintain the landscape at the geographic scales of watersheds to basins (from hundreds to thousands of square miles).

These processes include the movement of water, sediment, nutrients, pathogens, toxins, and wood as they enter, move through, and eventually leave the watershed.

Our management and regulation of these aquatic ecosystems have typically concentrated on the biological, physical, and chemical character of the individual lake, wetland, stream reach, or estuary, and not on the larger watershed that controls these characteristics.

Scientific studies have shown that watershed processes interact with landscape features, climate, and each other to produce the structure and functions of aquatic ecosystems that society is interested in protecting (Beechie and Bolton 1999). For example, flooding by streams can create off-channel habitat that is important for fish. Much of the research concludes that protection, management, and regulatory activities could be more successful if they incorporated an understanding of watershed processes.

Potential Uses

The final map showing priorities for protection and restoration could be used by the county to develop an initial suite of potential mitigation sites based on the sub-unit priority for protection and restoration. These mitigation sites can include aquatic resources such as wetlands and riparian areas as well as upland areas that are important to maintaining processes for these aquatic resources.

Lewis County planners and managers can also use this information in updating their Shoreline Master Program and Lewis County Comprehensive Growth Management Plan. For example, WAC 173-26-201(3)(d)(i)(A) (Shoreline Master Program Guidelines) requires local governments to prepare a characterization of ecosystem-wide processes and ecological functions and identify measures to protect and restore them. See Appendix B, Framework for Planning, for examples of applying characterization to local planning processes.

The characterization can also be used to develop comprehensive mitigation programs for Critical Area Ordinance updates (e.g., offsite mitigation, in lieu fees, transfer of development rights). This includes using the results from this characterization to establish service areas for mitigation banks. This approach should help sustain aquatic ecosystems by replacing and restoring functions within a common set of watersheds.

Results of Characterization

Identify Areas of Protection, Restoration, and Development

Land use planning should be developed within a framework that first focuses on maintaining or restoring watershed processes (Hidding and Teunissen 2002, Dale et al. 2000, Gove et al. 2001). To assist land use planning efforts in South Lewis County an initial watershed planning framework for protection, restoration, and development is presented below. This framework presents the areas that are most important within the study area for water flow processes.

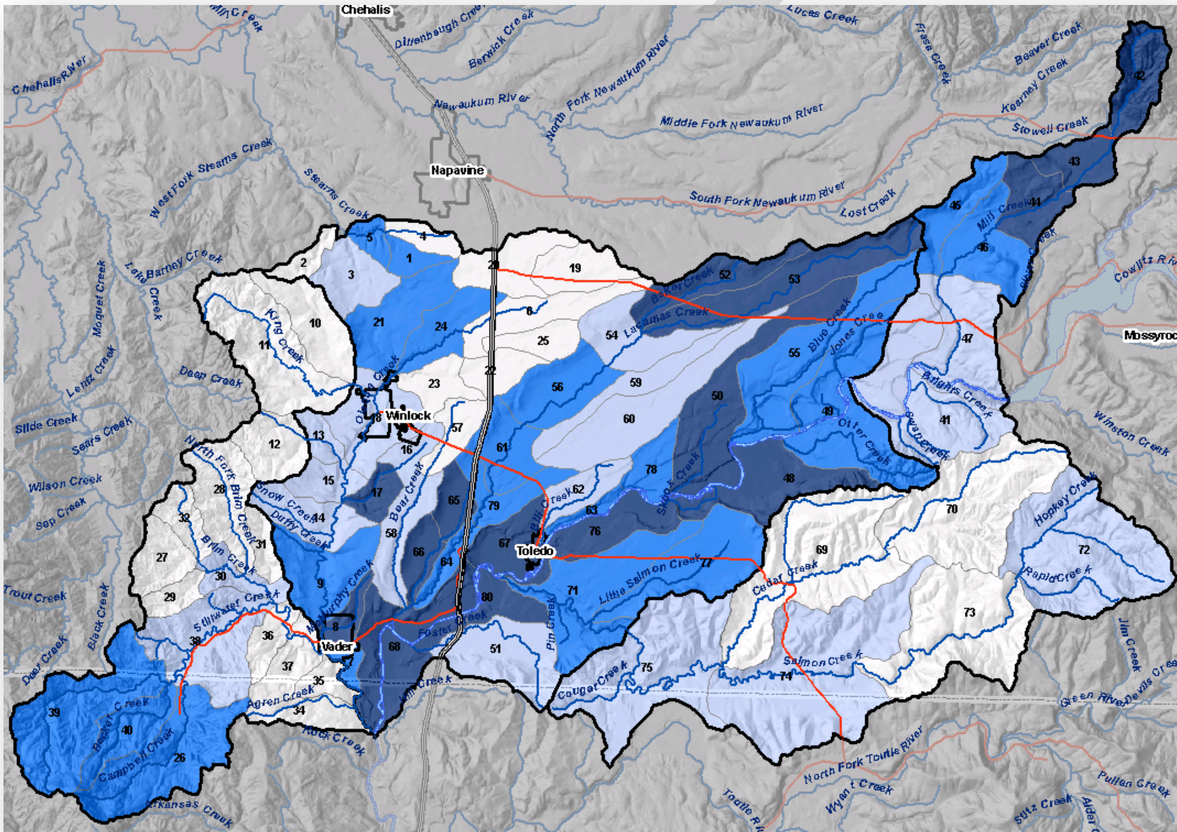


Figure 2: Rating of Areas Important for Water Flow Process. Areas in "dark blue" have the highest importance; areas in "blue" have moderate-high importance; areas in "light blue" have moderate importance; and areas in "white", lower importance.

Overall the areas in the terrace above and adjacent to the Cowlitz (blue area) are of moderate to high importance with areas primarily in the floodplain of the Cowlitz having high importance. Areas of moderate importance (yellow) are located predominately in the watersheds for the Olequa River south of and including Winlock. The mountainous areas are generally of moderate to lower importance for water flow process. However, the southwest corner (Becker and Campbell Creek watersheds) and northeast corner (Mill Creek watershed) of the analysis area are of moderate to high importance.

We discuss the potential areas for protection, restoration and development for the three Cities of Winlock, Vader, and Toledo in the synthesis section below. A summary of the results of the characterization are presented in Table 1.

***Protection*:** Any activity that ensures that **the watershed process remains relatively unimpaired**. This can encompass traditional efforts of protecting land from human activities (e.g., open space, conservation easements), but it can also mean designing development in a way that allows the watershed process to continue with minimal impairment. For instance, an area important for recharge could be set aside from any development, or new development could be sited and designed to ensure recharge of the additional surface runoff generated by the development.

Restoration: Any activity that ensures that **the watershed process is re-established or re-habilitated**. This can involve restoring the natural condition of an important area but it can also include activities that restore the capacity of the important area to support the process. For instance, an area important for recharge that is covered with impervious surfaces could be modified to accommodate recharge or it could be restored to natural conditions.

The specific design of any of these activities requires further site-level analysis.

Synthesis

In order to identify the most suitable areas for development, protection and restoration in South Lewis County, the results of the three different analyses were synthesized. This included characterization of water flow processes, wildlife habitat (Local Habitat Assessment) and assessment of buildable lands. A detailed review of the wildlife characterization (WDFW) and buildable lands assessment (Berryman and Henigar) are contained in separate reports.

Results of Fish and Wildlife Analysis

The Department of Fish and Wildlife characterized habitat at the broad and mid scales. For the broad scale, the Local Habitat Assessment found the majority of south Lewis County to have habitat of high suitability for wildlife. Generally, the areas with the lowest suitability were within the cities of Winlock, Toledo and Vader, and the road infrastructure and agricultural areas associated with these cities. The mid-scale analysis examined key species in the areas and their habitat needs. This included Oregon vesper sparrow, western meadowlark, northern flying squirrel, porcupine, merlin, bobcat and short eared owl. Additionally, forest edge and interior bird habitat and amphibian and reptile habitat was assessed.

Overall, south Lewis County was found to have a high suitability for wildlife habitat, including key wildlife species. The Lacamas Creek corridor was found to have the greatest significance both in terms of number of species present and productivity. This corridor is considered to be a very high importance to fish and wildlife and is shown in a “yellow” outline on the synthesis maps.

Buildable Lands Suitability Analysis

Parcels within the study area were evaluated for their development suitability based on a series of weighted factors, including distance from transportation corridors, zoning, and soils/slope. Results were presented in priorities from high to low suitability for development. The areas with the first and second highest suitability for development were used in this synthesis and are shown as “red” outlined areas on the synthesis maps.

Results of Synthesis

The synthesis maps displaying the results of combining characterization for water flow processes and wildlife habitat are presented in Figures 3 through 6. Data layers for all three analyses outlined above were combined and presented in four maps for different development scenarios:

- Alternative One. Areas of low importance for water flow processes plus #1 priority for buildable lands plus Lacamas Creek Fish and Wildlfe Corridor overlay;
- Alternative Two. Areas of low importance for water flow processes plus #1 and #2 priority for buildable lands plus Lacamas Creek Fish and Wildlife Corridor overlay;
- Alternative Three. Aresa of low and moderate importance for water flow process plus #1 and #2 priority for buildable lands plus Lacamas Creek Fish and Wildlife overlay.
- Areas of Development Conflict.

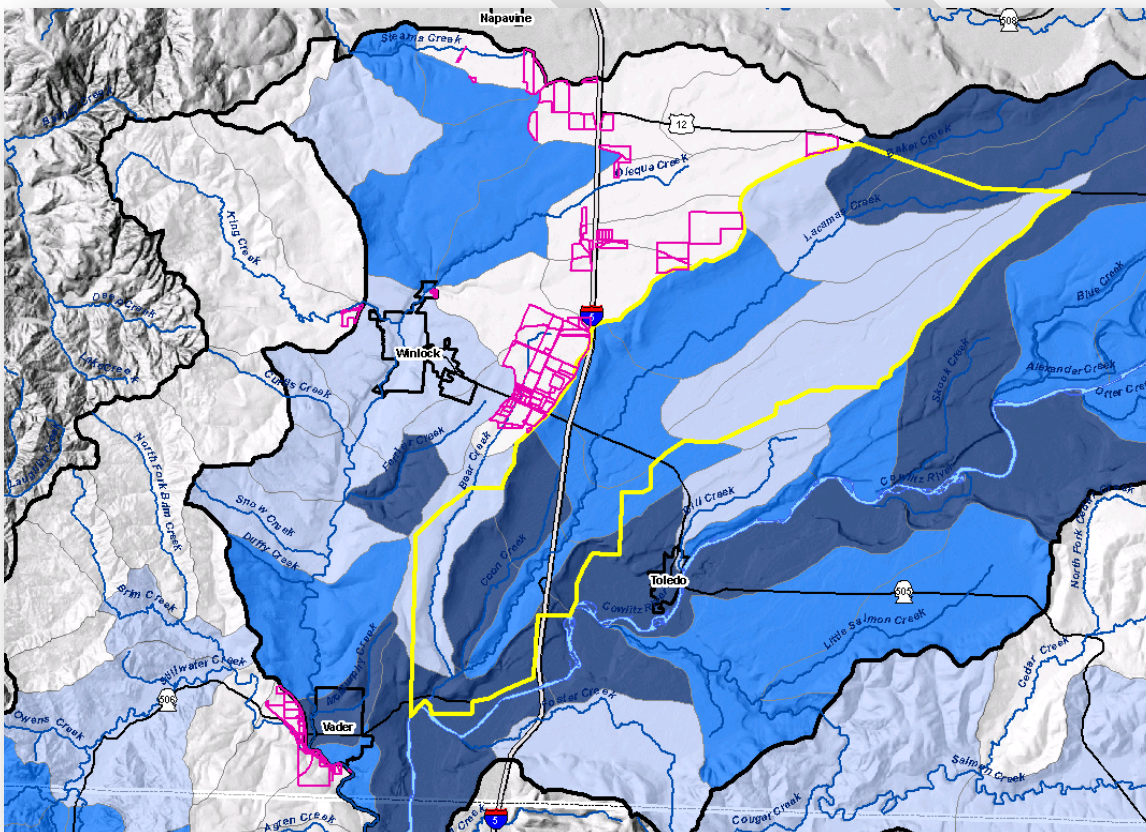


Figure 3 – Development Alternative 1. This alternative represents the lowest risk to south Lewis County ecosystems. Red outlined areas indicate parcels suitable for development. Buildable lands with the #1 priority development were combined with areas having the lowest importance for water flow processes. Dark blue represents highest importance for water flow processes and light blue the least. Yellow outline area is the Lacamas Creek fish and wildlife overlay; this area has a low suitability for development.

The first three development scenarios represent the most suitable areas within the study area for development. However, alternative one represents a lower risk to maintaining water flow processes and fish and wildlife habitat relative to alternative three. These alternatives can be used by the county to design the final subarea plan development plan and regulations.

Development alternatives 1 and 2 (Figure 3 and 4) identify the upper terrace (see figure C-1 and A-3) as the most suitable are for future development. This area has relatively lower permeability and storage , but large areas of wetlands in the headwater portion of Olequa Creek.

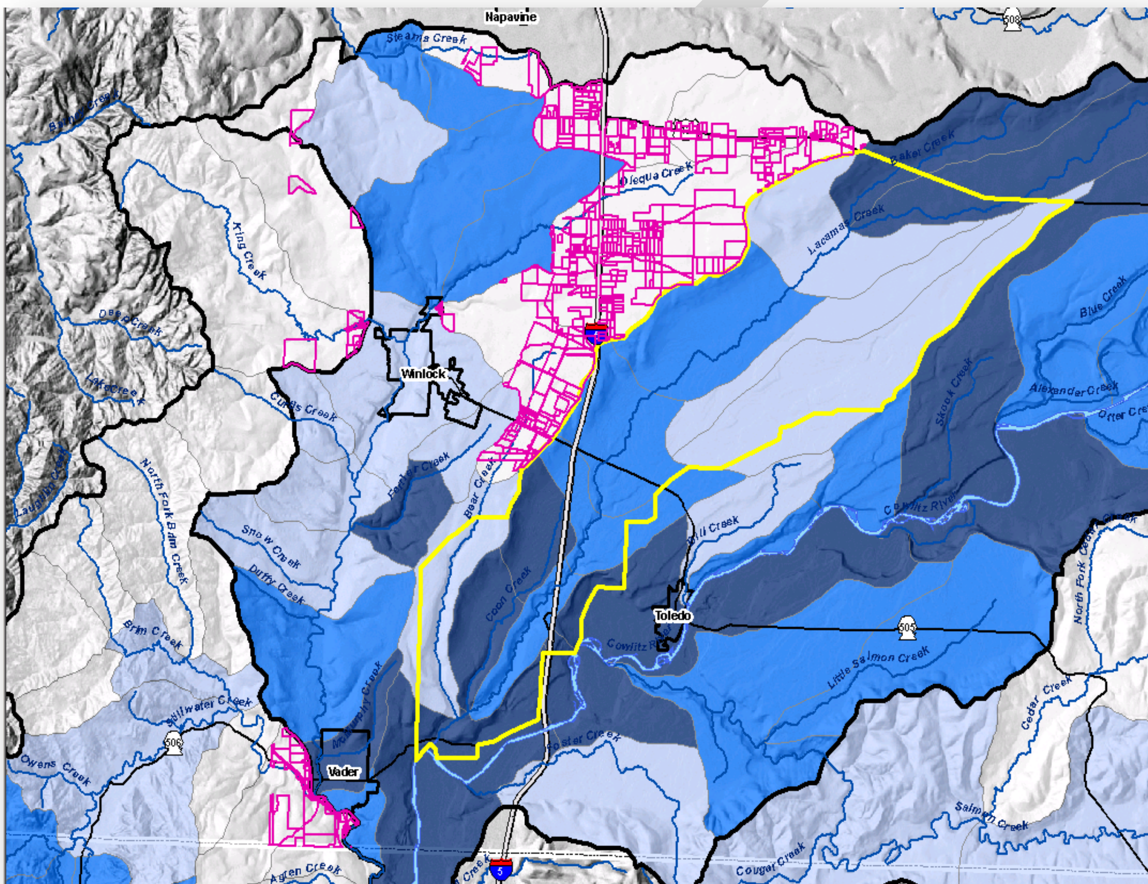


Figure 4. Development Alternative 2. This alternative represents a low risk to the south Lewis County ecosystems. Red outlined areas indicate parcels suitable for development. Buildable lands with the #1 and #2 priority for development were combined with areas having the lowest importance for water flow processes. Dark blue represents highest importance for water flow processes and light blue the least. Yellow outline area is the Lacamas Creek fish and wildlife overlay; this area has a low suitability for development.

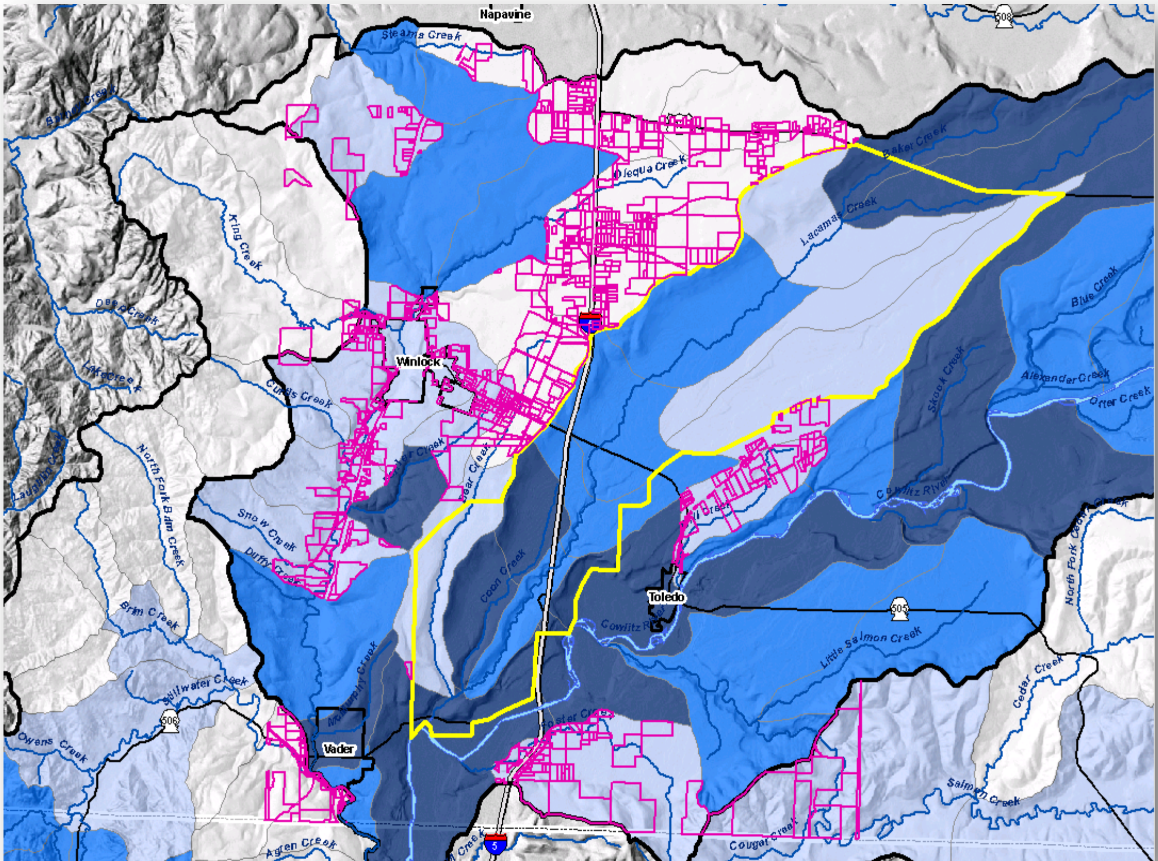


Figure 5. Development Alternative 3. This alternative represents a higher risk to the south Lewis County ecosystems. Red outlined areas indicate parcels suitable for development. Buildable lands with the #1 and #2 priority for development were combined with areas having the lowest and moderate importance for water flow processes. Dark blue represents highest importance for water flow processes and light blue the least. Yellow outline area is the Lacamas Creek fish and wildlife overlay; this area has a low suitability for development.

Figure 5 shows future development expanded into the intermediate terrace (Bill Creek) above Toledo, along the Olequa River south of Winlock and on Cougar and Foster Creeks.

Figure 6 shows the areas where development would have the greatest degree of conflict with the protection and restoration of water flow processes. It is recommended that the county select the type and intensity of development that is compatible with the protection and restoration of these processes.

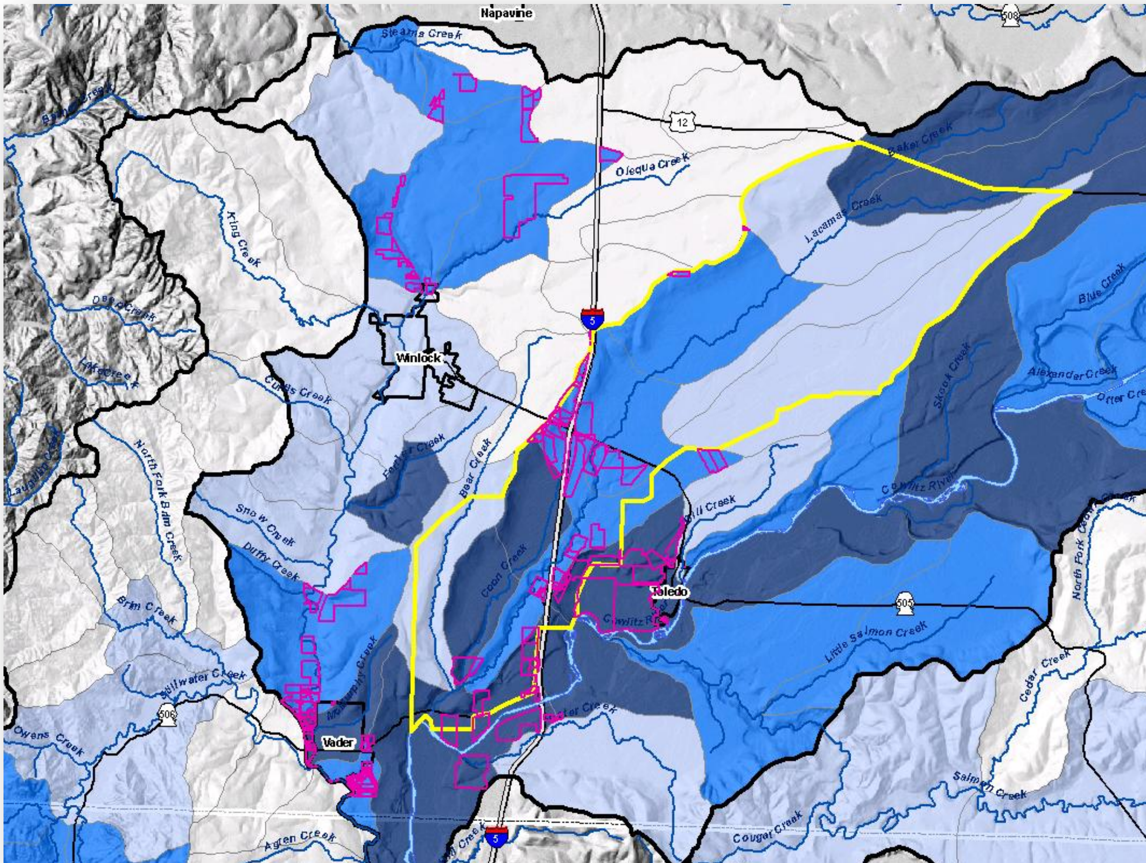


Figure 6 . Development Conflicts – Areas to Avoid. Areas that have a high to high/moderate importance for water flow processes and also parcels identified as buildable are depicted on this map. Red outlined areas indicate parcels suitable for development. Yellow outline area is the Lacamas Creek fish and wildlife overlay; this area has a low suitability for development.

Restoration and protection priorities

The synthesis of the important areas with the impairment maps provides information on the best locations for protection and restoration in south Lewis County. Figure 7 provides the results of this synthesis and Appendix C presents the details on the analysis of important and impaired areas.

The Cowlitz floodplain and the areas immediately above it include large areas ranked high priority for protection and restoration. This includes the Cowlitz River, Otter, Lacamas, lower Salmon, Mill, and Blue Creeks. In general, the mountainous watersheds and the upper terrace (north portion of watershed) generally ranked lower in restoration and protection priority. However, the Becker and Campbell Creek watersheds (southwestern corner of analysis area) and upper Mill Creek (northeast portion) ranked high for both protection and restoration.

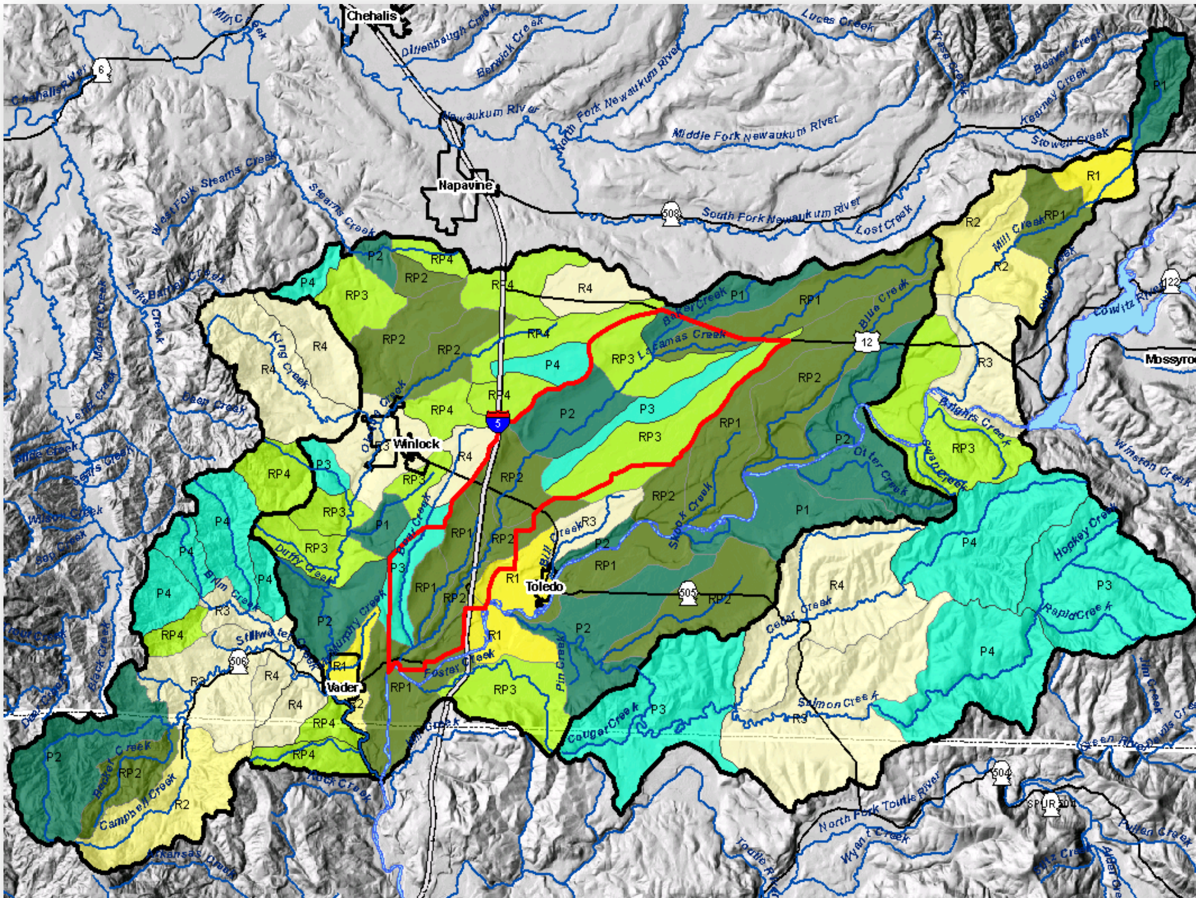


Figure 7. Ranking of Areas for Protection and Restoration for Water Flow Processes. Areas in "dark green" are suitable for protection; areas in "yellow" are suitable for restoration. Lighter greens represent different combinations of restoration and protection. P1 to P4 indicate first through fourth protection priorites. RP1 to RP4 indicate first through fourth restoration/protection priorities; and R1 through R4 represents first through fouth restoration priorities. The "red" outline areas identifies the Lacamas Creek Fish and Wildlife Conservation overlay.

Winlock

The areas most suitable for future development are located to the east of Winlock in sub-units 16, 23, and 56 (See Figure 8 for sub-basin numbers). These sub-units are of lower importance due to reduced areas of higher permeability and surface storage. Areas suitable for restoration may be located north of Winlock in the sub-units comprising the Olequa River. These areas are rated higher for importance due to the presence of large areas of surface storage (floodplains and wetlands) and have been impaired by clearing of riparian cover and draining of wetlands. Within the City of Winlock existing development has significantly impaired most water flow processes. Therefore, continued development (infill) with measures to encourage protection and restoration of existing streams and wetlands is recommended.

Vader

The areas most suitable for development in Vader are located to the west and southwest of town in sub-units 36 and 37. These sub-units are of lower importance due to reduced areas of higher permeability and surface storage. Areas for protection and restoration are located along McMurphy Creek located to the northeast of town (sub-unit 8) and to the south (sub-unit 7), and east (sub-unit 68). Within the City of Vader existing development has significantly impaired most water flow processes. Therefore, continued development (infill) with measures to encourage protection and restoration of existing streams and wetlands is recommended.

Toledo

On a relative basis sub-unit 62 (Bill Creek watershed) is the most suitable area for future development for the City of Toledo. This sub-unit has a moderate rating for importance due to the presence of wetlands (contribute to surface storage), but has reduced permeability. Again, water flow processes are significantly impaired within the existing city so infill is appropriate. Key areas for restoration, within the historic and existing floodplain of the Cowlitz River, are located immediately west and south of the city.

WRIA 25 and 26 Basin Plan Recommendations

The Basin Plan includes the lower Cowlitz, upper Cowlitz, Cispus, Tilton, Toutle, and Coweeman watersheds. One or more populations of tule fall Chinook, bright fall Chinook, spring Chinook, chum, winter steelhead, summer steelhead, and coho are present and many need to be restored to high levels of viability to meet regional recovery objectives. The Basin Plan for WRIA's 25 and 26 set forth the following priority actions:

- Restoring access above dams in the upper portion of the basin,
- Protecting intact forests in headwaters,
- **Managing forest land to protect and restore watershed processes**, consistent with existing and future land use regulations and authorities,
- **Managing growth and development to protect watershed processes** and habitat conditions,
- Restoring passage at culverts and other artificial barriers,
- Restoring lowland floodplain function, riparian conditions, and stream habitat diversity,
- Addressing immediate risks with short term habitat fixes,
- Aligning hatchery priorities with conservation objectives, and
- Reducing out-of-sub-basin impacts.

Recomendations

In order to adequately implement the results of this characterization, development standards and regulations must be drafted that allow for mitigation and restoration offsite. This is necessary, since many of the highest priority opportunities for protection and restoration are located outside of areas that will experience the highest degree of development. If "credits" for mitigation can be transferred to sub-basins that will provide for a greater degree of process restoration, this will be a greater benefit to the ecosystem relative to onsite mitigation. It is suggested that the County consider the following:

1. Revising the Critical Areas Ordinance to include a policy allowing for the adoption of a watershed based subarea plan and its regulations. Model language for this, from the Whatcom County CAO, Title 16, section 16.16.260 E of the County code, is partially as follows:

   "A watershed-based management plan and/or an alternative mitigation plan for a major development, planned unit development or developer agreement shall be allowed to substitute for the standards and requirements of this chapter when approved by the designated decision maker as per County Code. "

2. The CAO would also contain the following provisions:
   a. Allow for the transfer of development credits from areas that have high importance, habitat significance (i.e. Lacamas Creek Wildlife overlay) or development conflicts, to areas shown as having suitability for development (Figures 3 through 5).
   b. Allow for the clustering of residential development on areas of higher importance outside of urban rural boundaries. This could involve the clustering of residences on 0.5 acre or less parcels with a conservation easement placed on the balance of the existing subdivided parcels that would have one residence each (e.g. Five 10 acre lots would have a conservation easement on 45 acres with 5 residences clustered on 5 acres)..
   c. Application of green infrastructure measures in the terrace areas to maintain infiltration processes.
3. To maximum extent feasible, implementation of the recommendations of the WRIA 25 and 26 Basin Plan including:
   a. Protection of headwater forests and wetlands, especially for Olequa Creek
   b. Restoring watershed processes in managed forest lands.
4. Maintaining and restoring habitat in the Lacamas Creek Fish and Wildlife overlay area (Figure 3-5).consistent with the recommendations of the WDFW characterization report.

Table of Results for Water Processes

Table 1 summarizes the results of the characterization for water flow processes. The table lists the the sub-basin number which can be located on Figure 8 and the sub-basin name based on the stream system present. Both the importance score and corresponding "high, medium or low" rating is provided. The last column presents the protection and restoration rating based on the synthesis of the results of the importance and impairment maps. Apprendix C outlines the method for this synthesis. The definition for the acronyms used in the column are as follows: P1 through P4, is protection priority 1 through 4; RP1 through RP4 is a combination of restoration/protection priority 1 through 4; and R1 through R4 is restoration priority 1 through 4.

Table 1 –Summary Results for Water Process

Basin Number	Name of Sub-basin	Geo_unit	Importance Score 0-1	Importance Rating H,M,L	Impaired Score 0-1	Impaired Rating H,M,L	Protection Restoration Rating
1	BUNKER CREEK	Terrace	0.67	MH	0.50	M	RP2
2	BUNKER CREEK	Terrace	0.03	L	0.00	L	P4
3	BUNKER CREEK	Terrace	0.49	M	0.36	M	RP3
4	BUNKER CREEK	Terrace	0.24	L	0.35	M	RP4
5	BUNKER CREEK	Terrace	0.64	MH	0.14	L	P2
6	OLEQUA	Terrace	0.16	L	0.43	M	RP4
7	OLEQUA	Terrace	0.60	MH	1.00	H	R2
8	OLEQUA	Terrace	0.91	H	0.77	H	R1
9	OLEQUA	Terrace	0.63	MH	0.21	L	P2
10	OLEQUA	Mtn	0.07	L	0.51	MH	R4
11	OLEQUA	Mtn	0.19	L	0.52	MH	R4
12	OLEQUA	Mtn	0.00	L	0.49	M	RP4
13	OLEQUA	Terrace	0.29	M	0.23	L	P3
14	OLEQUA	Terrace	0.47	M	0.30	M	RP3
15	OLEQUA	Terrace	0.44	M	0.35	M	RP3
16	OLEQUA	Terrace	0.29	M	0.43	M	RP3
17	OLEQUA	Terrace	0.86	H	0.21	L	P1
18	OLEQUA	Terrace	0.41	M	0.76	H	R3
19	OLEQUA	Terrace	0.00	L	0.54	MH	R4
20	OLEQUA	Terrace	0.19	L	0.40	M	RP4
21	OLEQUA	Terrace	0.56	MH	0.36	M	RP2
22	OLEQUA	Terrace	0.19	L	0.50	M	RP4
23	OLEQUA	Terrace	0.16	L	0.44	M	RP4
24	OLEQUA	Terrace	0.59	MH	0.36	M	RP2
25	OLEQUA	Terrace	0.09	L	0.17	L	P4
26	STILLWATER	Mtn	0.57	MH	0.76	H	R2
27	STILLWATER	Mtn	0.21	L	0.07	L	P4
28	STILLWATER	Mtn	0.05	L	0.15	L	P4
29	STILLWATER	Mtn	0.14	L	0.32	M	RP4
30	STILLWATER	Mtn	0.31	M	0.72	MH	R3
31	STILLWATER	Mtn	0.08	L	0.16	L	P4
32	STILLWATER	Mtn	0.16	L	0.25	L	P4
34	STILLWATER	Mtn	0.10	L	0.42	M	RP4

Number	Name	Geo unit	Imp Score	Rating	Imp Scor	Rating	Prot Rest
35	STILLWATER	Mtn	0.05	L	0.47	M	RP4
36	STILLWATER	Mtn	0.23	L	0.52	MH	R4
37	STILLWATER	Mtn	0.17	L	0.51	MH	R4
38	STILLWATER	Mtn	0.31	M	0.56	MH	R3
39	STILLWATER	Mtn	0.60	MH	0.24	L	P2
40	STILLWATER	Mtn	0.57	MH	0.40	M	RP2
41	MILL CREEK	Mtn	0.48	M	0.47	M	RP3
42	MILL CREEK	Mtn	0.86	H	0.12	L	P1
43	MILL CREEK	Mtn	1.00	H	0.76	H	R1
44	MILL CREEK	Mtn	0.77	H	0.34	M	RP1
45	MILL CREEK	Mtn	0.60	MH	0.54	MH	R2
46	MILL CREEK	Mtn	0.62	MH	0.52	MH	R2
47	MILL CREEK	Mtn	0.42	M	1.00	H	R3
48	MILL CREEK	Terrace	0.93	H	0.14	L	P1
49	MILL CREEK	Terrace	0.64	MH	0.17	L	P2
50	LACAMAS	Terrace	0.80	H	0.33	M	RP1
51	LACAMAS	Terrace	0.47	M	0.46	M	RP3
52	LACAMAS	Terrace	0.99	H	0.20	L	P1
53	LACAMAS	Terrace	0.76	H	0.35	M	RP1
54	LACAMAS	Terrace	0.36	M	0.26	M	RP3
55	LACAMAS	Terrace	0.73	MH	0.30	M	RP2
56	LACAMAS	Terrace	0.71	MH	0.24	L	P2
57	LACAMAS	Terrace	0.24	L	0.52	MH	R4
58	LACAMAS	Terrace	0.44	M	0.13	L	P3
59	LACAMAS	Terrace	0.36	M	0.10	L	P3
60	LACAMAS	Terrace	0.30	M	0.36	M	RP3
61	LACAMAS	Terrace	0.71	MH	0.43	M	RP2
62	LACAMAS	Terrace	0.41	M	0.83	H	R3
63	LACAMAS	Terrace	0.63	MH	0.25	L	P2
64	LACAMAS	Terrace	0.64	MH	0.38	M	RP2
65	LACAMAS	Terrace	0.99	H	0.32	M	RP1
66	LACAMAS	Terrace	0.91	H	0.31	M	RP1
67	LACAMAS	Terrace	0.93	H	0.79	H	R1
68	LACAMAS	Terrace	0.91	H	0.45	M	RP1
69	CEDAR CREEK	Mtn	0.24	L	0.62	MH	R4
70	CEDAR CREEK	Mtn	0.15	L	0.00	L	P4
71	SALMON CREEK	Terrace	0.71	MH	0.25	L	P2
72	SALMON CREEK	Mtn	0.28	M	0.16	L	P3
73	SALMON CREEK	Mtn	0.08	L	0.06	L	P4
74	SALMON CREEK	Mtn	0.28	M	0.59	MH	R3
75	SALMON CREEK	Mtn	0.35	M	0.22	L	P3
76	SALMON CREEK	Terrace	0.96	H	0.33	M	RP1
77	SALMON CREEK	Terrace	0.57	MH	0.36	M	RP2
78	LACAMAS	Terrace	0.54	MH	0.35	M	RP2
79	LACAMAS	Terrace	0.51	MH	0.46	M	RP2
80	LACAMAS	Terrace	1.00	H	0.63	MH	R1

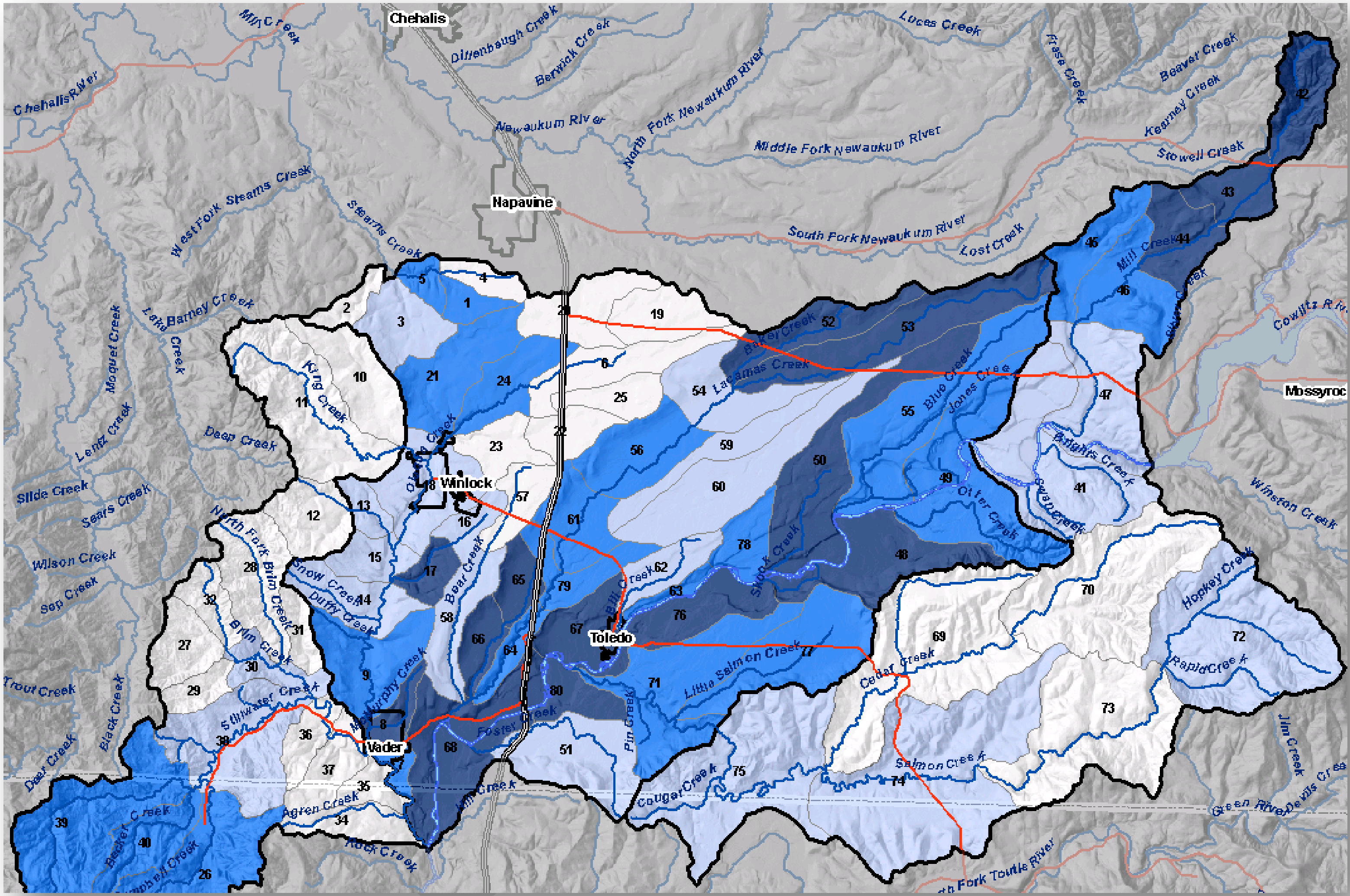


Table 8. Importance Map with Sub-basin Numbers. To be used in conjunction with Table 1

References:

Bedford, B.L. 1999. Cumulative effect on wetland landscapes: links to wetland restoration in the United States and Southern Canada. Wetlands 19(4):775-788

Bedford, B.L. and E.M. Preston. 1988. Developing the scientific basis for assessing cumulative effects of wetland loss and degradation on landscape functions: Status, perspectives and prospects. Environmental Management 12(5): 751-771.

Beechie, T. and S. Bolton. 1999. An approach to restoring salmonid habitat-forming processes in Pacific Northwest watersheds. Fisheries Habitat 24:6-15.

Dale, V.H., S. Brown, R.A. Haeuber, N.T. Hobbs, N. Huntly, R.J. Naiman, W.E. Riebsame, M.G. Turner, and T.J. Valone. 2000. Ecological principles and guidelines for managing the use of land. Ecological Applications 10(3): 639-670.

Gersib, R. 2001. The need for process-driven, watershed-based wetland restoration in Washington State. Proceedings of the Puget Sound Research Conference 2001.

Gove, N.E., R.T. Edwards, and L.L. Conquest. 2001. Effects of scale on land use and water quality relationships: A longitudinal basin-wide perspective. Journal of the American Water Resources Association 37(6):1721 – 1734.

Hidding, M.C. and Teunissen, A.T.J. 2002. Beyond fragmentation: new concepts for urban-rural development. Landscape and Urban Planning, 58(2/4): 297-308.

National Research Council. 2001. Committee on Mitigating Wetland Losses. Compensating for wetland losses under the Clean Water Act. Washington, D.C.: National Academy Press. 348 pp.

Poiani, K.A., B.D. Richter, M.G. Anderson, and H.E. Richter. 1996. Biodiversity conservation at multiple scales: Functional sites, landscapes, and networks. Bioscience 50(2): 133-146.

Roni, P., T.J. Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollock, and G.R. Pess. 2002. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. North American Journal of Fisheries Management 22. 1-20 pp.

Stanley, S., J. Brown, and S. Grigsby. 2005. Protecting aquatic resources, Volume 1. A guide for Puget Sound planners to understand watershed processes. Department of Ecology Publication 05-06-027.

Stanley, S., T. Hruby, and S. Grigsby. 2006. Protecting aquatic resources, Volume 2. Models for understanding watershed processes. In review.

Weigle, J.M. and B.L. Fowworthy. 1962. Geology and Ground-Water Resources of West-Central Lewis County, Washington. State of Washington Department of Conservations, Division of Water Resources. Water Supply Bulletin No. 17. 248 pgs.

Whatcom County Shoreline Master Program Update. 2006. Shoreline Inventory and Characterization.

Winter, T.C. 2001. The concept of hydrologic landscapes. Journal of the American Water Resources Association 37(2):335-348.

Appendix A. Methods for Characterization

Methods

The approach used for this project is described in Ecology publication #05-06-027, "Protecting Aquatic Ecosystems By Understanding Watershed Processes: A Guide for Planners." This document provides guidance on how to conduct a coarse-scale characterization for multiple watershed processes. Appendix B and C of this publication also present the models used to score hydrologic and denitrification processes.

The appendices provide tables describing the individual components of each process, as well as human activities that are impairments to the process. Three processes, water, nitrogen, and pathogens, also have numeric models that can identify the areas in a watershed that are more important to maintaining that process, and areas where that process is most impaired. The equations in these models use the environmental characteristics described in the tables as variables that establish the relative level of importance and impairment.

Variables receive maximum values of 1, 2, or 3, representing low, medium, or high importance of a characteristic or impairment of a characteristic. The models reflect that a higher total score represents a sub-unit of greater importance for supporting a process in a watershed, or one with a higher degree of impairment to that process.

In general, scoring is normalized to conditions within in a watershed or basin. However, indicators of importance or impairment are based on peer-reviewed research suggesting regional thresholds for certain process components (e.g., minimum wetland area and relationship to affecting surface water flows). Thus, the models provide a *comparison* of the *relative level of importance and impairment* of process components (see Steps 3 and 4 of Ecology publication #05-06-027). The scores do not represent a specific rate (e.g., rate of removal of sediment or nitrogen) or specific level of impairment of a process, and cannot be compared to scores outside of the analysis area. We do not have enough information at this time to calibrate models to conditions throughout the state and establish relative importance of processes and impairments among different watersheds.

Appendix B of this document presents a series of maps that display the results of the individual models applied to Lewis County. See the appendices in Ecology publication #05-06-027 for descriptions of the scoring methods.

Hydrogeologic Units (HG)

This characterization uses a hydrogeologic classification approach based on the "hydrologic-landscapes" described by Winter (2001) and the hydrogeologic work of Bedford (1999 & 1988). This landscape approach considers regional climate, surficial geology, topography (landform), groundwater and surface flow patterns and morphology in relationship to aquatic resources. This report uses precipitation type, landform, geology, and surface water/groundwater patterns to develop hydrogeologic units.

In order to maintain the relationship between processes and the aquatic ecosystems that they influence (i.e., process, structure and function relationship), this study modifies this existing classification scheme for hydrogeologic units by adding precipitation type and surface/groundwater patterns to geology and landform.

These modified hydrogeologic units were divided so that watersheds with significantly different patterns of precipitation and geomorphology were not compared to one another during the scoring process. For example, because the watersheds within the mountainous portions of the study area have higher precipitation patterns including rain-on-snow zones, they will score higher than the rain dominated Terrace units if analyzed together. The Terrace units, however, support important aquatic ecosystems and should be characterized separately from the mountainous watersheds so that characterization scores are not artificially suppressed by the scores for the higher precipitation levels in the study area.

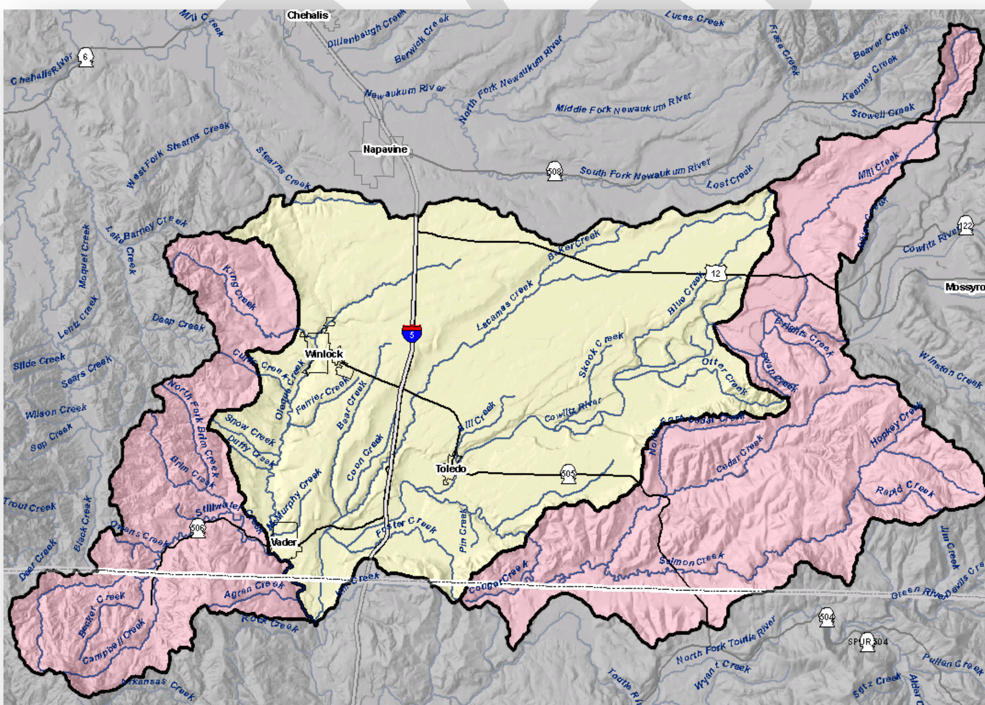


Figure A-1. Hydrogeologic Units (HG). The pink unit is the Rain-on-snow and rain-dominated Mountainous unit; yellow unit is the Rain-dominated Terrace unit.

There are two HG units (see Figure B-1) used in the South Lewis County characterization. The western-most and southeastern units are characterized by rain-on-snow and rain dominated precipitation, generally shallow groundwater flow patterns, consolidated bedrock, and steep topography. This is called the "Rain-on-snow and rain-dominated" Mountainous unit.

The second unit includes the lowland terraces above the Cowlitz and Olequa River systems. This unit is dominated by rain, and has a westward to southeastern trending groundwater flow pattern towards the Cowlitz River.

The geology, landform, and groundwater flow patterns of these units are discussed in further detail below.

Geology and Landforms

The description of the geology of the study area is based on the work of Weigle and Foxworthy (1962). The study area is located within the Puget Trough which extends from Oregon northward to British Columbia. It is underlain by bedrock consisting of lava flows and pyroclastic and marine sedimentary rocks. These older rocks are overlain by relatively deep deposits of alluvium and drift originating from alpine glaciers in the adjacent Cascades Mountains. These younger deposits are located on terraces adjacent to the Cowlitz River and Olequa River. The benches and terraces in the study area were formed during the Pleistocene by glacially fed streams and rivers discharging across a basin filled with silt, sand and gravel.

Figure A-2 shows the major landforms for the study area. They consist of foothills or mountainous areas, upland plains, intermediate terraces, and floodplains. The upland terraces or plains are the oldest and have experienced the greatest degree of erosion. They have rolling hills and deep gullies (i.e. Winlock, Vader) and are represented by the Jackson and Grand Prairies.

The intermediate plains have been subject to less erosion and are relatively flat as a result. This includes the Lacamas Creek terrace, which is the largest intermediate terrace in Lewis County. It is approximately 150 feet lower than the Jackson Prairie and 200 to 450 higher than the floodplain of the Cowlitz.

The Cowlitz floodplain and associated low elevation terraces are broad, extending to 2 miles width in places.

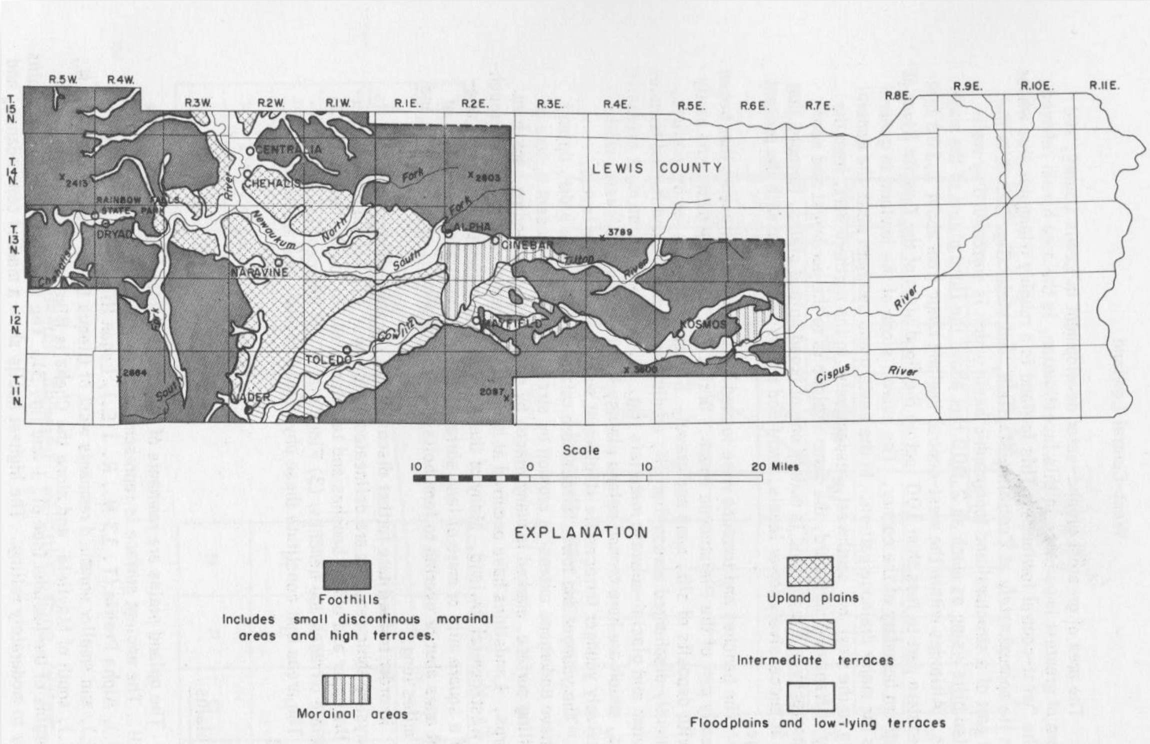


Figure A-2. Landforms for South Lewis County. Major landforms consist of upland plains, intermediate terraces and foothills or mountainous areas. Source: Water Supply Bulletin No. 17.

Groundwater Flow Patterns

Figure A-3 presents the generalized geology for the study area on a cross-section running south from Napaville to just east of Toledo. A general pattern of intermediate groundwater flow can be determined using this map. The pink "Tu" unit is bedrock and acts as a controlling surface in directing groundwater flow generally towards the Cowlitz River. The overlying deposits (Qlh, Qlc, Qnt, Qlp, Qt) have varying degrees of permeability and water yield, with the oldest most weathered deposits (Qlh – Logan Hill Formation) having lower permeability and water yield and younger deposits such as the Qlc having higher permeabilities and yields.

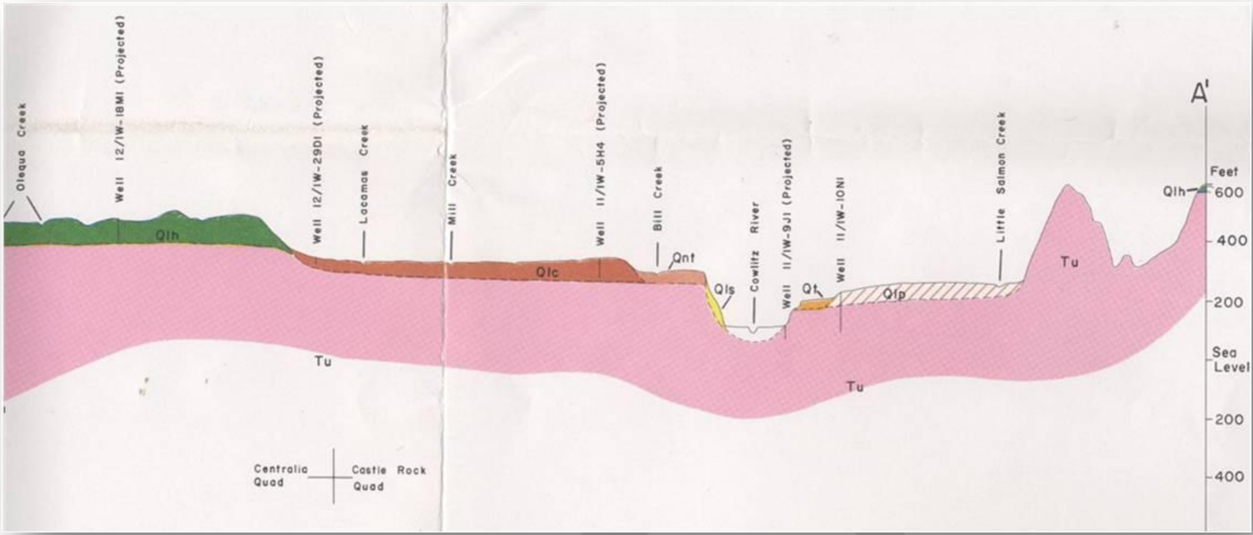


Figure A-3. Generalized depiction of geology for south Lewis County. Cross-section running south from Napaville to just east of Toledo. Pink "Tu" units represents bedrock which generally controls flow of groundwater towards the Cowlitz River. Qlh represents the Logan Hill formations which is the most weathered of the terrace formations. Qlc represents the Logan Hill formation which is less weathered and more permeable; this area would be a discharge zone for the Qlc formation above it. Qnt is the Newaukum formation and has high permeability and yields large quantities of water. Qlp is the Layton Prairie unit and yields high quantities of groundwater. Source: Water Supply Bulletin No. 17.

Appendix B. Framework for Planning

Framework for planning

Successful watershed planning uses larger scale information (i.e. the characterization) to help identify planning solutions at smaller scales. To accomplish this, a watershed based planning framework, as presented below, should be applied. A more detailed discussion of this planning framework is presented in "Guidance for Protecting and Managing Wetlands in Western Washington", Volume 2, Chapters 4 and 5 (Granger et al. 2005).

The methods described in this document for mapping important areas and relative impairments to watershed processes address the first box of the diagram above, "Characterize Watershed Processes." Planners can then use this information to develop preliminary solutions (box 2, "Prescribe Solutions") including alternative scenarios for development/ management. Examples include:

- Selecting the appropriate types and intensity of development for different locations
- Changing zoning to better protect the ecological services provided by the environment
- Identifying the best locations for mitigation
- Identifying the types of mitigation needed in different areas
- Locating the best areas for cost-effective restoration.

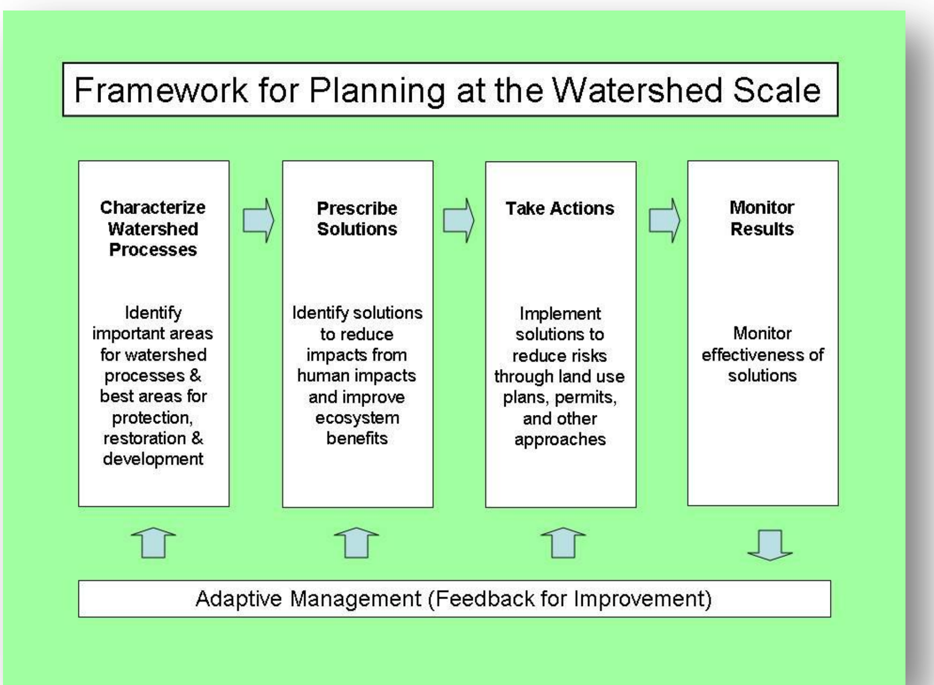


Figure B-1 – Framework for Planning at the Watershed Scale. The four main steps for developing a watershed based plan.

When scenarios for future development and management are analyzed, locally reviewed, and accepted, the solutions can be incorporated in Shoreline Master Program and/or Comprehensive Plan updates and implemented through the regulatory process . The final, and most important step in the framework, is monitoring the results of the adopted plan. This determines if the provisions of the plan are effectively protecting and/or restoring aquatic ecosystems. Feedback from this monitoring effort can be used to modify or "adapt" the plan to correct those aspects that are not meeting the objectives of protection and restoration.

Examples of Use of a Planning Framework by Other Jurisdictions

Whatcom, King, and Jefferson counties are presently using a framework for planning at the watershed scale as part of their Shoreline Master Programs (SMP) updates. These jurisdictions are using variations of earlier versions of the characterization models outlined in Ecology Publication 05-06-027. The Whatcom County Council adopted their draft SMP on February 27, 2007. The draft SMP characterization and restoration reports (Appendix C, Volumes I and II) are available at the following site:

http://www.co.whatcom.wa.us/pds/shorelines_critical_areas/workproducts.jsp

Whatcom County's characterization work provided information necessary to: 1) select appropriate environment designations and development standards for shoreline areas and 2) develop watershed-based restoration and protection recommendations for shoreline resources. Figure B-2 displays the important areas identified for the hydrology process in Whatcom County at the watershed scale. Using this information, as well as a characterization of the level of impairment, the county developed tables providing recommendations at a reach scale for protection and restoration measures and environment designations (Figure B-3).

A draft watershed management plan was developed by Whatcom County in 2007 for the Birch Bay watershed. Using a watershed based characterization of both hydrologic processes and wildlife, the plan identified protection, restoration and development management zones (Figure B-4).

Additionally, specific measures for restoration of processes were proposed for each sub-unit within the study area. The County is in the process of preparing regulatory and non-regulatory measures to implement the management plan. The draft management plan is available at the following site:

http://www.co.whatcom.wa.us/pds/shorelines_critical_areas/pdf/CompleteBBCharacter_Public Draft.pdf

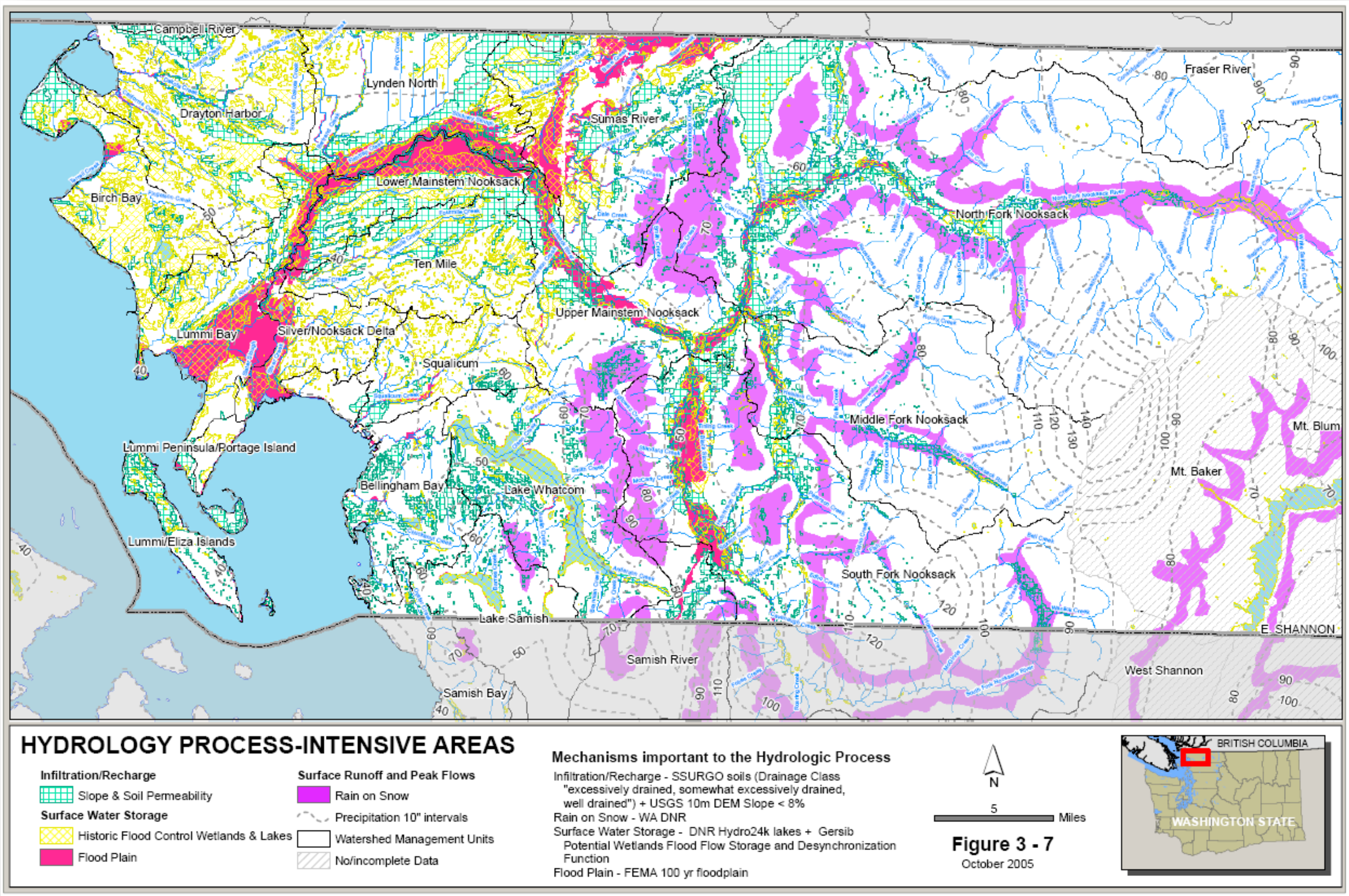


Figure B-2. Example of characterization map for water process. (Whatcom County). This map was developed using methods described in the Department of Ecology publication # 05-06-027 (Protecting Aquatic Ecosystems). This map, along with maps for four other watershed processes, was used to develop SMP protection and restoration measures (Figure B-3).

ıle 7-1. Summary of Process Intensity and Alterations by Drainage Area, Upper Mainstem Nooksack WMU

Process		Process Intensity*																						
		Hydrology								Sediment						Water Quality				LWD		Heat/Light		
Mechanism		Infiltration & Recharge		Surface Water Storage		Snowmelt and Runoff		Ground-water		Mass Wasting		Surface Erosion		Storage		Inputs		Storage		LWDRP		Canopy Cover		
Intensity		Process	Alteration	Process	Alteration	Process	Alteration	Process	Alteration	Process	Alteration	Process	Alteration	Process	Alteration	Process	Alteration	Process	Alteration	Process	Alteration	Process	Alteration	Potential for Restoration and Protection
1	Lower Nooksack Floodplain	↑	↓	↑	↓	↓	↓	↑	↔	↓	↓	↓	↔	↑	↓	↓	↔	↑	↓	↔	↑	↓	↑	This portion of the Nooksack Mainstem has significant, intact riparian wetlands, but armoring and levees likely limit surface, hyporheic, and groundwater interactions between the river and its floodplain. Strategic levee setbacks accompanied by riparian restoration may help restore natural stream morphology and improve habitat.
2	Smith Creek	↓	↓	↓	↓	↑	↓	↓	↓	↓	↔	↓	↓	↓	↓	↓	↓	↓	↓	↑	↓	↑	↑	Upper Smith Creek is relatively unimpaired by forest practices. Lower Smith Creek lies on the Nooksack floodplain, and has a hydrologic connection to the larger river system. Restoring /preserving connectivity in the lower drainage may improve functions in both the Nooksack and the creek.
3	Lower Anderson Creek	↔	↓	↔	↑	↓	↓	↔	↔	↓	↓	↓	↓	↔	↑	↓	↔	↔	↑	↑	↔	↑	↔	Restoring lost wetlands and riparian areas in lower Anderson Creek has the potential to improve water quality, water quantity, and habitat complexity.
4	Upper Anderson Creek	↓	↓	↓	↓	↑	↑	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑	↓	↑	↔	The upper Anderson Creek is relatively unimpaired by forest practices. Protection of rain-on-snow zones and landslide hazard areas is recommended to prevent increased disturbance regime.
5	Upper Nooksack Floodplain	↑	↔	↑	↔	↓	↓	↑	↔	↓	↓	↓	↔	↑	↔	↓	↔	↑	↔	↔	↑	↓	↑	Riparian restoration is the key component for re-establishing natural geomorphology. Such restoration will likely succeed only in the context of reduced sediment supply from upstream sources. The area in the vicinity of Smith Creek is highly altered and may provide significant opportunities for restoration projects.
6	Other Tributaries	↓	↓	↓	↓	↔	↔	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑	↓	↑	↔	These are typically short, steep tributaries upstream of the major tributaries. Opportunities for restoration may be more limited.

Red: High restoration potential: Moderate to high process intensity with high degree of alteration

Blue: Moderate restoration potential: -- Moderate to high process intensity with moderate degree of alteration; OR low process intensity with high degree of alteration

White: Low restoration potential: Low process intensity with low to moderate degree of alteration

Gold: High protection potential: Moderate to high process intensity with low degree of alteration

* Function responses to alteration of these processes tend to be less dependent on the level of process-intensity, which is historically low in Whatcom County. Therefore, the assessment of restoration potential is based primarily on the degree of alteration.

Reach	Existing SEDs	Recommended SEDs		Comment
		Left Bank	Right Bank	
Reach 16	Conservancy	Resource/ Conservancy	Conservancy	Rural near downstream end of Reach 16 near Everson, otherwise Conservancy designation will protect existing process-intensive areas
Reaches 17-19	Conservancy/ Tribal	Conservancy/ Tribal	Conservancy/Tribal	

Recommended SMP environment designations for upper mainstem Nooksack Water Management Unit based on characterization results. Includes the upper and lower Nooksack floodplains listed in table 7-1 above. The characterization suggested important areas for several watershed processes including removal of nitrogen (water quality), surface water and sediment storage and recharge

Figure B-3. Protection and Restoration Measures. The upper table was used by Whatcom County to summarize watershed characterization results for the upper mainstem Nooksack Water Management Unit. Components for each process are evaluated based on intensity/importance of the processes, the degree of impairment, and the potential for protection and restoration. This table was then used to help determine appropriate land-use designation (lower table) for shoreline reaches and specific restoration measures in a separate restoration plan.

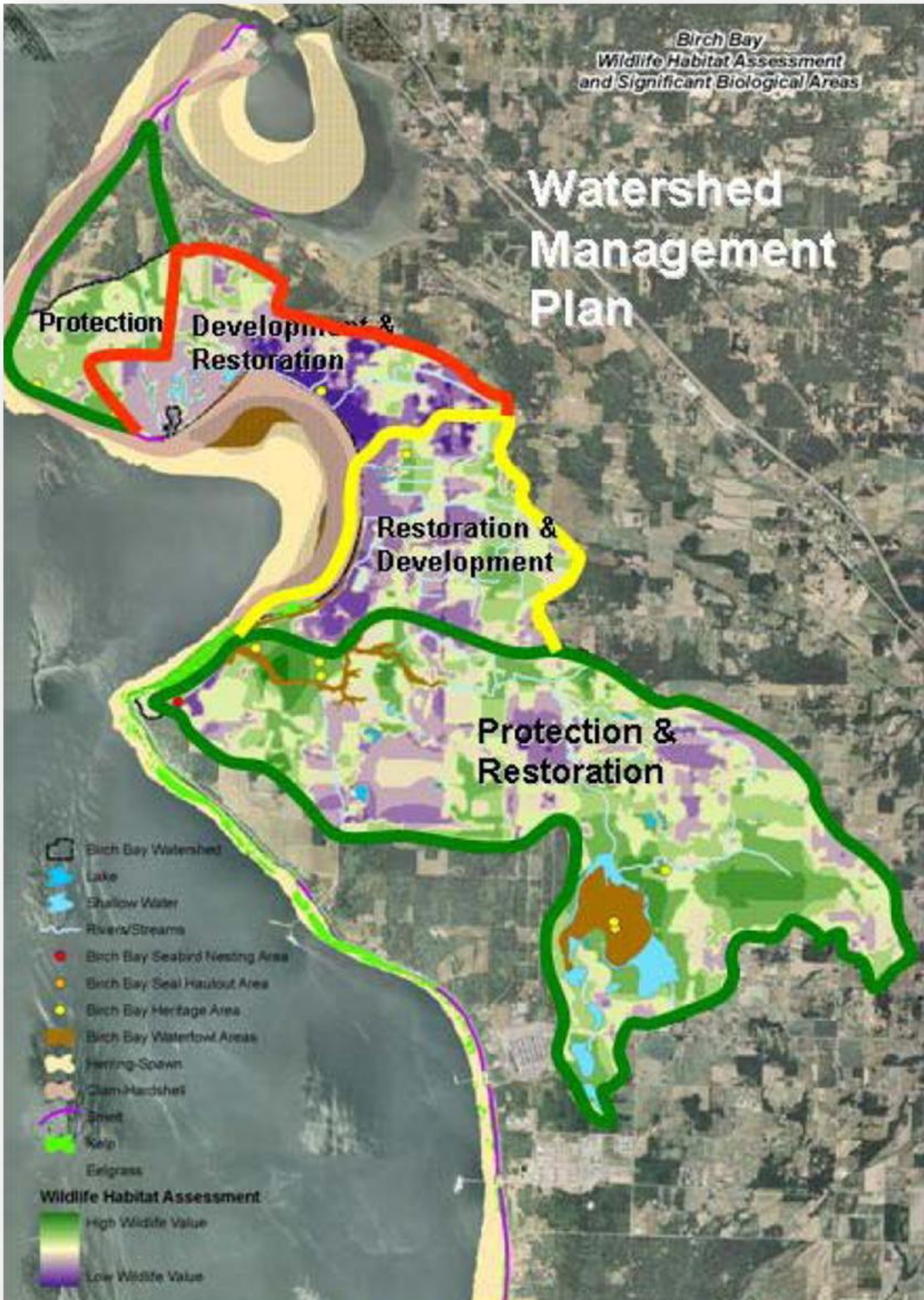


Figure B-4. Draft Management Plan for Birch Bay, Whatcom County.

Appendix C. Detailed Results of Characterization

C-1.0 Areas of Importance to the Hydrologic Process

Figures C-1 and C-2 depict the final score for areas of high, moderately high, moderate, and low importance to the hydrologic process. This section will discuss the basis for the level of importance for subunits for each hydrogeologic unit (Figure A-1) in the analysis area.

Terrace Hydrogeologic Unit

The Terrace hydrogeologic unit is located in the central portion of the analysis area, extending northeast, and includes the towns of Winlock, Vader, and Toledo (Figure C-1). It steps down in elevation through a series of three terraces towards the alluvial floodplain of the Cowlitz River.

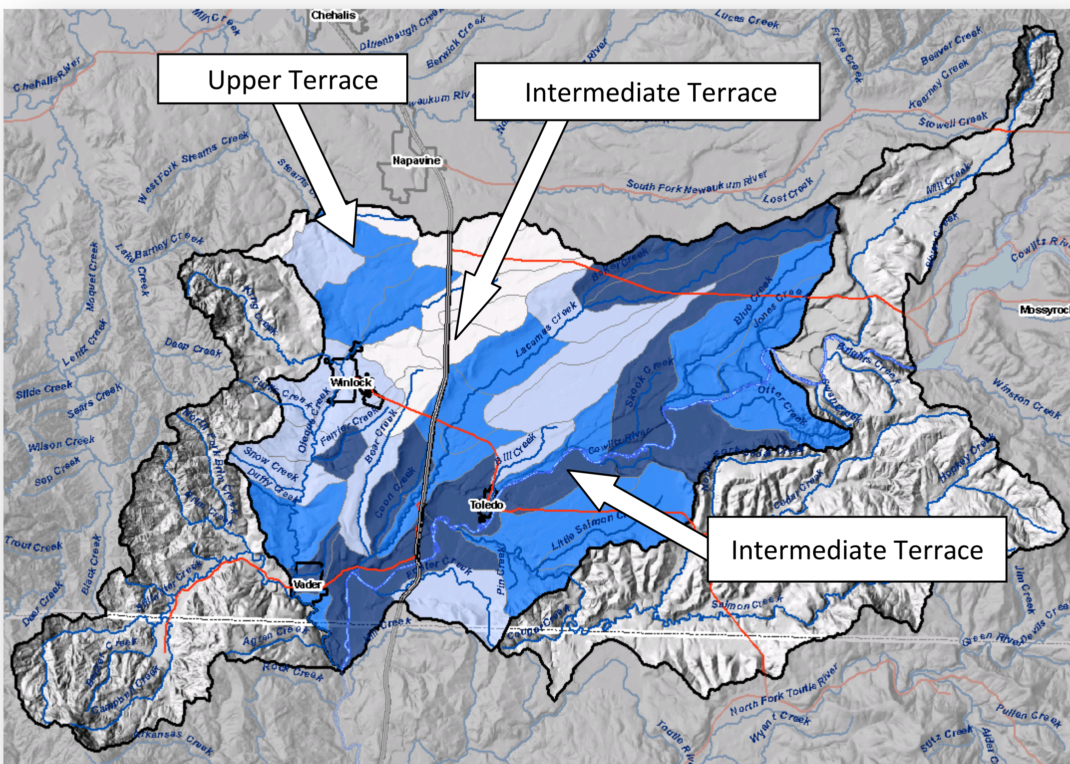


Figure C-1. Rating of Importance for the Hydrologic Process in the Terrace. Areas in "dark blue" have the highest importance; areas in "blue " have moderate-high importance; areas in "light blue" have moderate importance; and areas in "white", lower importance.

The upper terrace is primarily of moderate importance to the hydrologic process. It is highly weathered and tends to have deposits of lower permeability, lower infiltration rates, and lower precipitation levels (Figure C-6), especially in its northeast portion. The presence of a low gradient, broader floodplain and weathering, in the northeast portion of this terrace at the headwaters of Olequa Creek, has lead to the formation of wetlands (Figure C-10). These characteristics provide considerable surface storage and a moderate level of infiltration. Here, groundwater moves towards the Olequa River and also southeast towards the intermediate terrace (i.e. Lacamas Creek). Subunits 3, 5, 6, 20, 21, 22, and 24 received a rating of moderate importance based on these characteristics.

As you move south of Winlock, downstream on the Olequa River toward Vader, the subunits increase to moderately high and high importance. This southern portion of the upper terrace has higher permeability (Figure C-8), higher rainfall (Figure C-6) and fewer wetlands (Figure C-10). This is an important area for infiltration and recharge. Subunits 7, 9, 17, and 8 received a rating of moderate-high to high based on these characteristics.

The intermediate terrace area is located north of the Cowlitz River and supports Lacamas, Bill, Bear, Blue, and Skook Creeks, and contains the town of Toledo. It is characterized primarily as moderately high and high for importance in Figure C-1. This terrace is an important area for discharge of groundwater originating from the upper terrace to the northwest. As a result of this discharge, large areas of hydric soil (Figure C-9) and wetlands (Figure C-10) dominate the Lacamas Creek watershed. The discharge also supports flows in Lacamas Creek. This area provides considerable area for surface storage (i.e. depressional wetlands) and has greater rainfall than the higher elevation terrace to the northwest. Deposits of higher permeability are present in the headwaters of Lacamas and Blue Creek. Recharged groundwater in this terrace moves towards and discharges in the lower elevation Cowlitz alluvial floodplain. Based on these characteristics, subunits 56 and 59 were ranked high in importance and the balance of subunits ranked moderate-high except for subunits 58 and 62 (i.e. moderate ranking for Bear and Bill Creeks).

The Cowlitz floodplain is comprised primarily of alluvial and outwash deposits (Figure C-7) and shows primarily as red areas in Figure C-1. Because this floodplain is located below the intermediate terraces it is a significant area for groundwater discharge. The higher permeability deposits in the floodplain (Figure C-8) facilitate groundwater discharge and recharge. These characteristics result in the largest contiguous area ranked as high in importance (Subunits 48, 50, 63, 76, 80, 68) with the rest of the sub-units ranking moderate-high in importance.

Another intermediate terrace is located southeast of the Cowlitz River and it has considerable areas of higher permeability deposits (Figure C-8) and wetlands (Figure C-10). This terrace area provides both surface storage and recharge and supports groundwater discharge in the adjacent Cowlitz River floodplain. Additionally, there are large areas of groundwater discharge at the base of the mountainous unit where it intersects this intermediate terrace. This discharge has created a long continuous band of hydric soils (Figure C-9) and wetlands (Figure C-10). Based on these characteristics, these subunits were ranked of moderate to moderate-high importance (51, 71, 48).

Mountainous Hydrogeologic Unit

The rain dominated mountainous unit is comprised primarily of bedrock (Figure C-7) and has markedly higher precipitation levels than that of the Terrace Unit. Areas of higher permeability

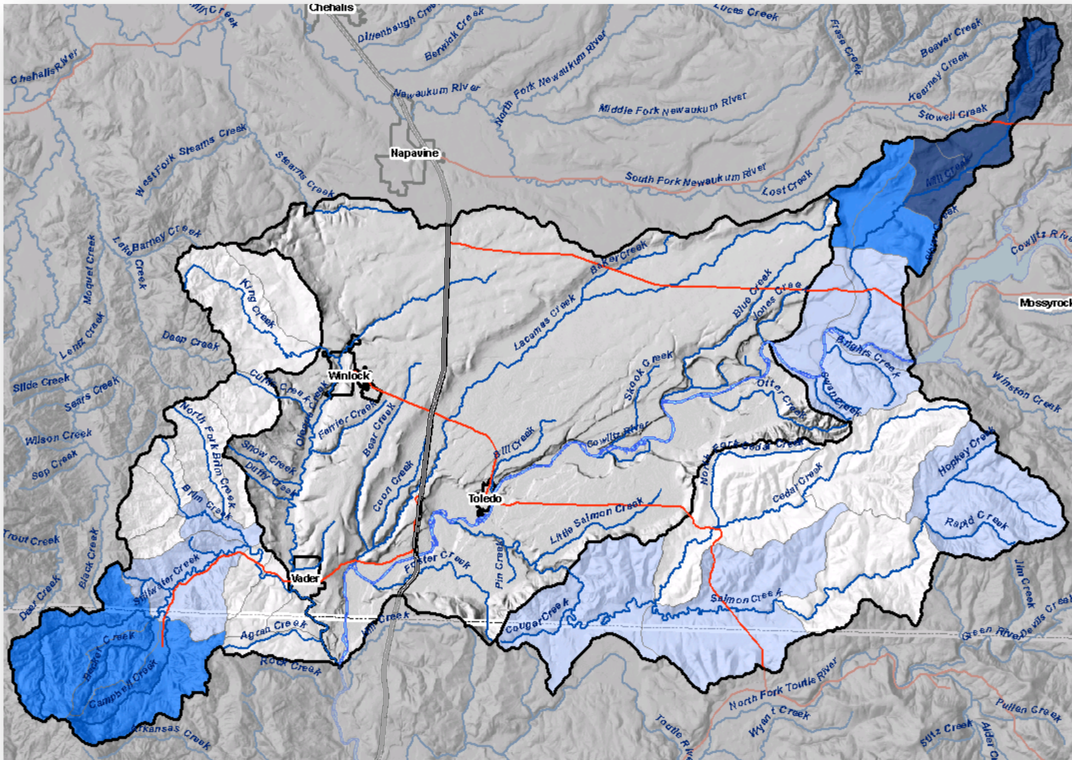


Figure C-2. Rating of Importance for the Hydrologic Process in the Mountainous Unit. Areas in "dark blue" have the highest importance; areas in "blue" have moderate-high importance; areas in "light blue" have moderate importance; and areas in "white", lower importance.

are limited in the southern portion of the unit but increase in the north eastern and southwestern and western portions of the unit (Figure C-6). Wetlands are not as prevalent and are mainly concentrated in creek floodplains (Figure C-10). The areas with higher precipitation and higher permeability were rated from moderate to high importance (subunits 26, 39, 40, 41, 42, 43, 45, 46 and 47). The balance of the subunits ranked lower in importance.

C-2.0 Areas of Impairment to the Hydrologic Process

Figures C-3 and C-4 depict the final score for areas of high, moderately high, moderate, and low impairment to the hydrologic process. The impairment score includes consideration of areas of forest clearing and impervious surfaces and rating of wetland and stream impacts. The relative degree of impairment for each hydrogeologic unit is discussed below.

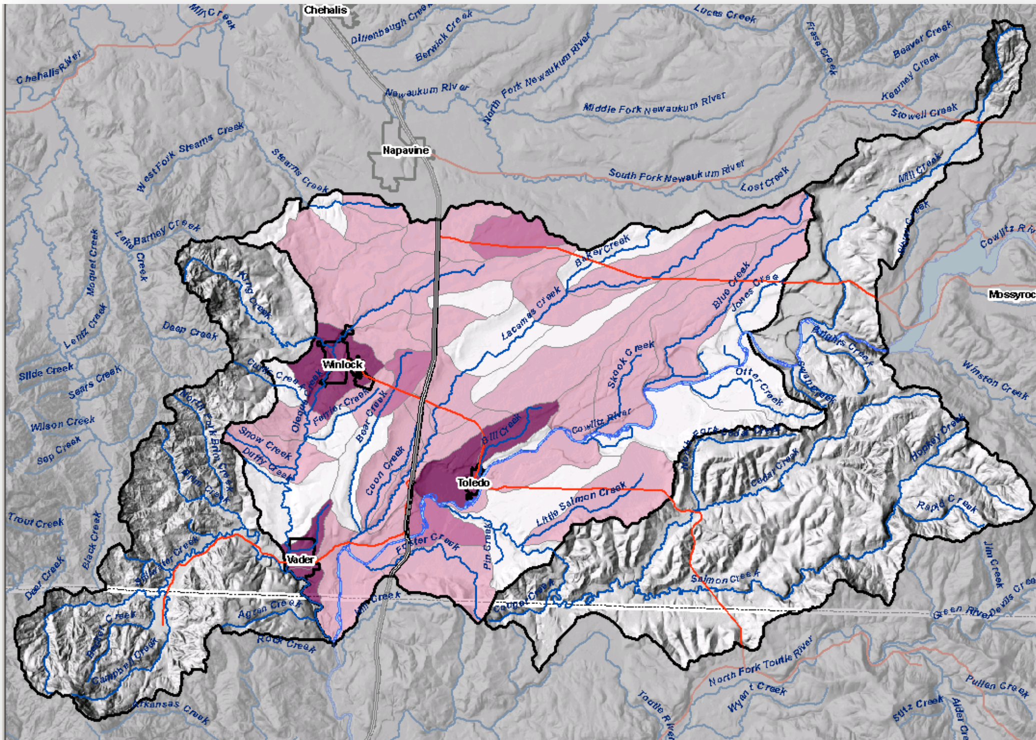


Figure C-3. Rating of Impairment for the Hydrologic Process in the Terrace Unit. Final Score. Lightest = lowest levels of impairment and darkest = highest impairment. (HI_M2_GU)

Terrace Hydrogeologic Unit

For the Terrace unit, high levels of impairment are present within the towns of Winlock, Vader, and Toledo. This is due to impervious surfaces, roads and clearing of forest. Outside of these urban areas, impairment is predominately moderate due to forest clearing for agriculture and rural residential. Areas of low impairment are present in the upper Lacamas Creek watershed (subunits 52, 54, 56, 59), Otter Creek (subunit 48, 49), Pin Creek (subunit 71), Bear Creek (subunit 58, 66), and McMurphy Creek (subunit 9). Impairment is moderate to moderate -high in the Cowlitz floodplain due primarily to clearing of riparian forest for agriculture.

Mountainous Hydrogeologic Unit

For the Mountainous unit, the most significant causes of impairment are from forest loss and road density. Both of these factors are reflected in the overall impairment to groundwater, since they affect recharge and shallow sub-surface water movement. The highest levels of impairment are present in subunit 47, at the confluence of Mill Creek with the Cowlitz River as it exits Mayfield Lake just below the dam (Figure C-4). Subunits 69 and 74, in the mid reaches of the Salmon and Cedar Creek basins, have moderately high impairment due to forest activity. Results are similar in the lower Stillwater subunits (30, 36, 38) and Campbell Creek (26). The majority of the Cedar and Salmon and the Cougar Creek watersheds have relatively low impairment to the water flow processes.

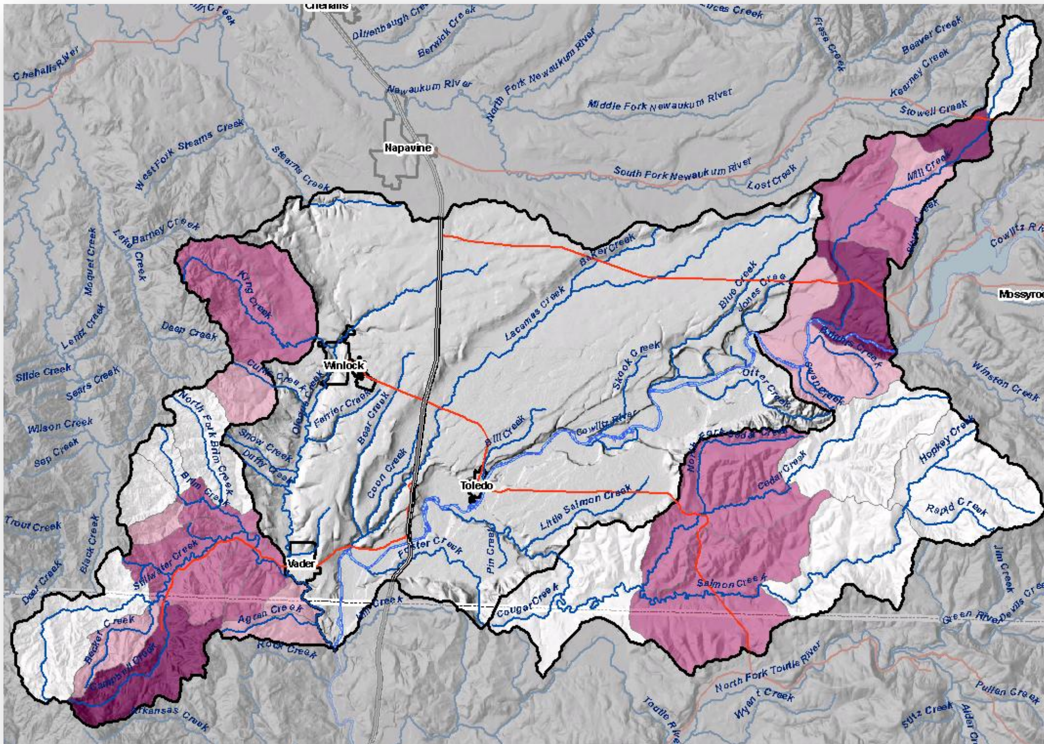


Figure C-4. Rating of Impairment for the Hydrologic Process in the Mountainous Unit. Final Score. Lightest = lowest levels of impairment and darkest = highest impairment. (HI_M2_GU)

Results of Other Watershed Assessments of Impairment

The current characterization for South Lewis County (Toledo, Vader, Winlock) generally concurs with the overall pattern of impairment shown in the Lower Columbia Salmon Recovery Plan (Figure C-5). However, because the current characterization focuses on a smaller analysis area and uses a method of relative comparison of impacts to calibrate the categories of impairment, it shows a greater range in the degree of impairment.

The Lower Columbia Salmon Recovery and Fish & Wildlife Sub-unit Plan (2004), identified the majority of sub-units within the lower Cowlitz watershed as impaired (Figure C-5). The Lower Columbia Salmon Recovery Plan relies on thresholds for non-forest cover, percent impervious surfaces, and road density to calculate the categories of functional, moderately impaired, and impaired. This characterization uses equivalent indicators of impairment.

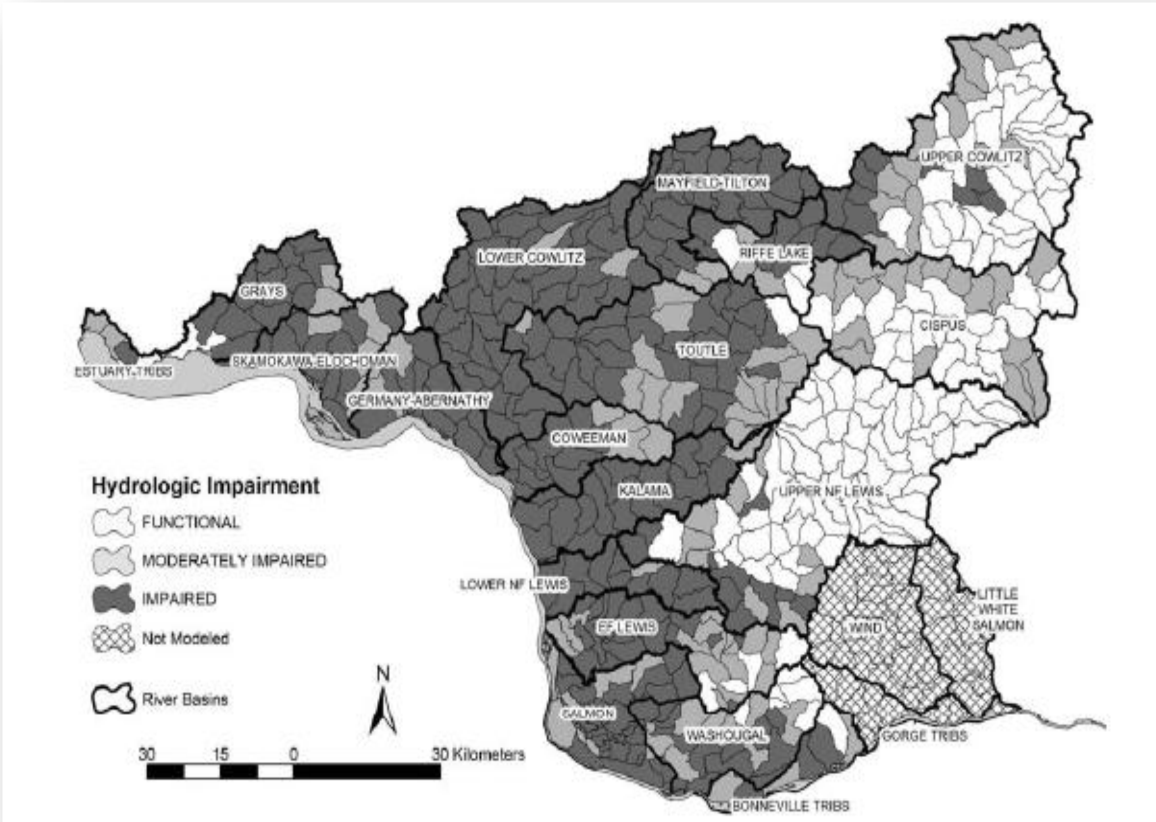


Figure C-5. Hydrologic Impairments for Watersheds in the Lower Columbia Region (Lower Columbia Salmon and Fish & Wildlife Recovery Plan 2004). The Integrated Watershed Assessment was used by this study to calculate degree of hydrologic impairment (Chapter 3, Limiting Factors and Threats, Figure 2).

Synthesizing Results of Importance and Impairment Maps

Figure C-6 depicts the detailed matrix for synthesizing the results of the importance and impairment maps for the hydrologic process. A matrix is used to create the protection and restoration map (Figure 7). The matrix is based on watershed-based research indicating that areas with low levels of impairment to watershed processes should be protected and areas with higher levels of impairment to processes with a higher level of importance should be restored (Stanley et al. 2005). Restoration should not have a high priority, however, in areas that have permanently impaired processes (urban areas with buildings and impervious surfaces).

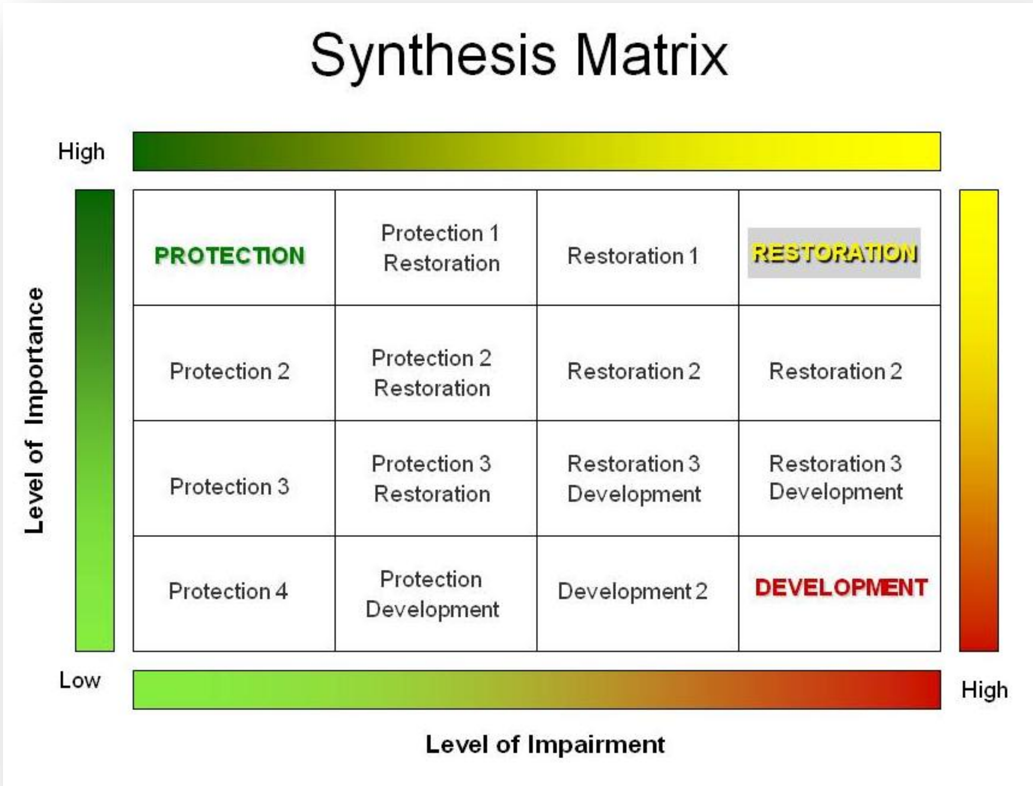


Figure C-6. Detailed analysis matrix for creating final restoration and protection map for the water flow processes..

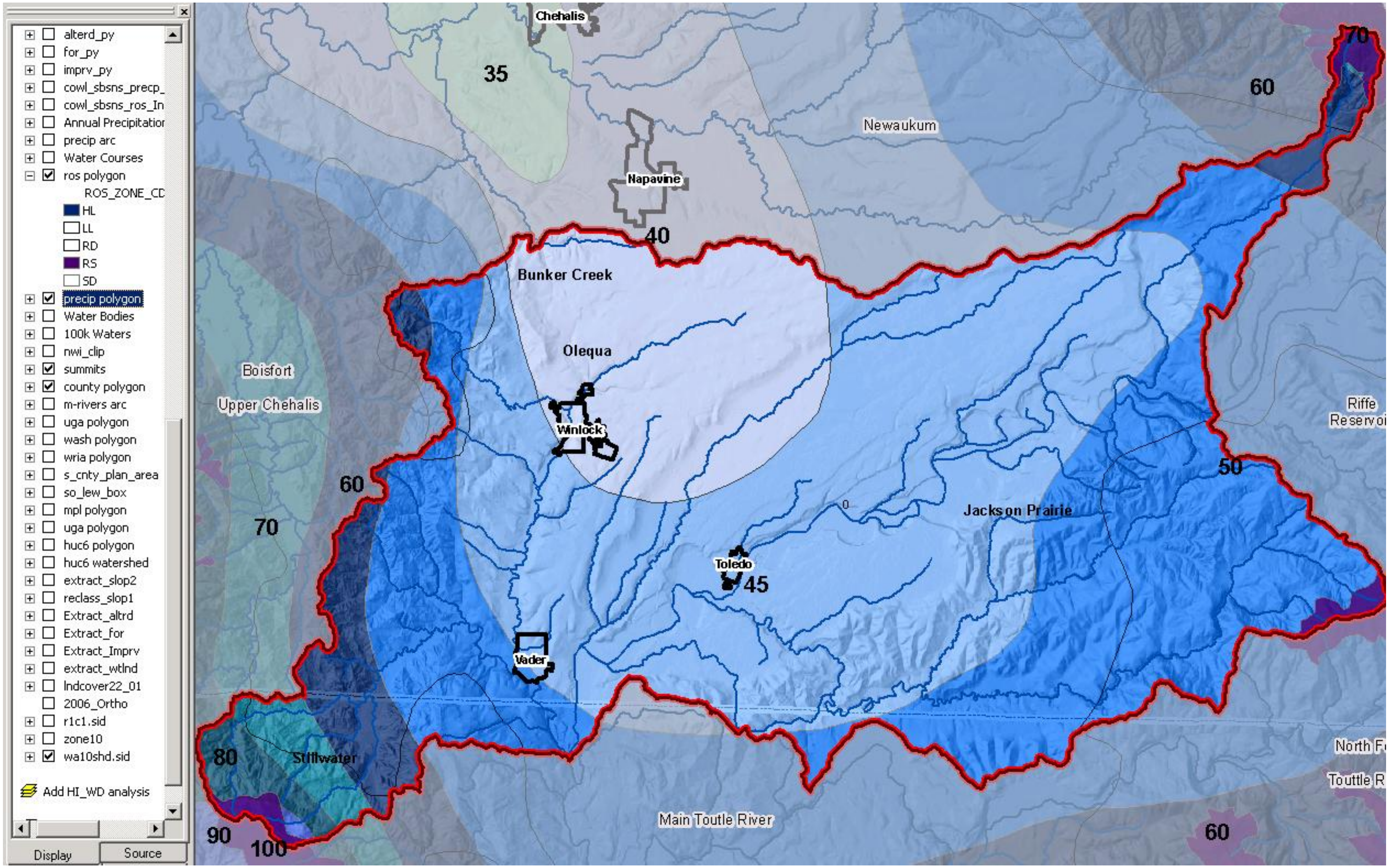


Figure C-6. Precipitation Levels for South Lewis County. Darker colors represent higher levels of precipitation.

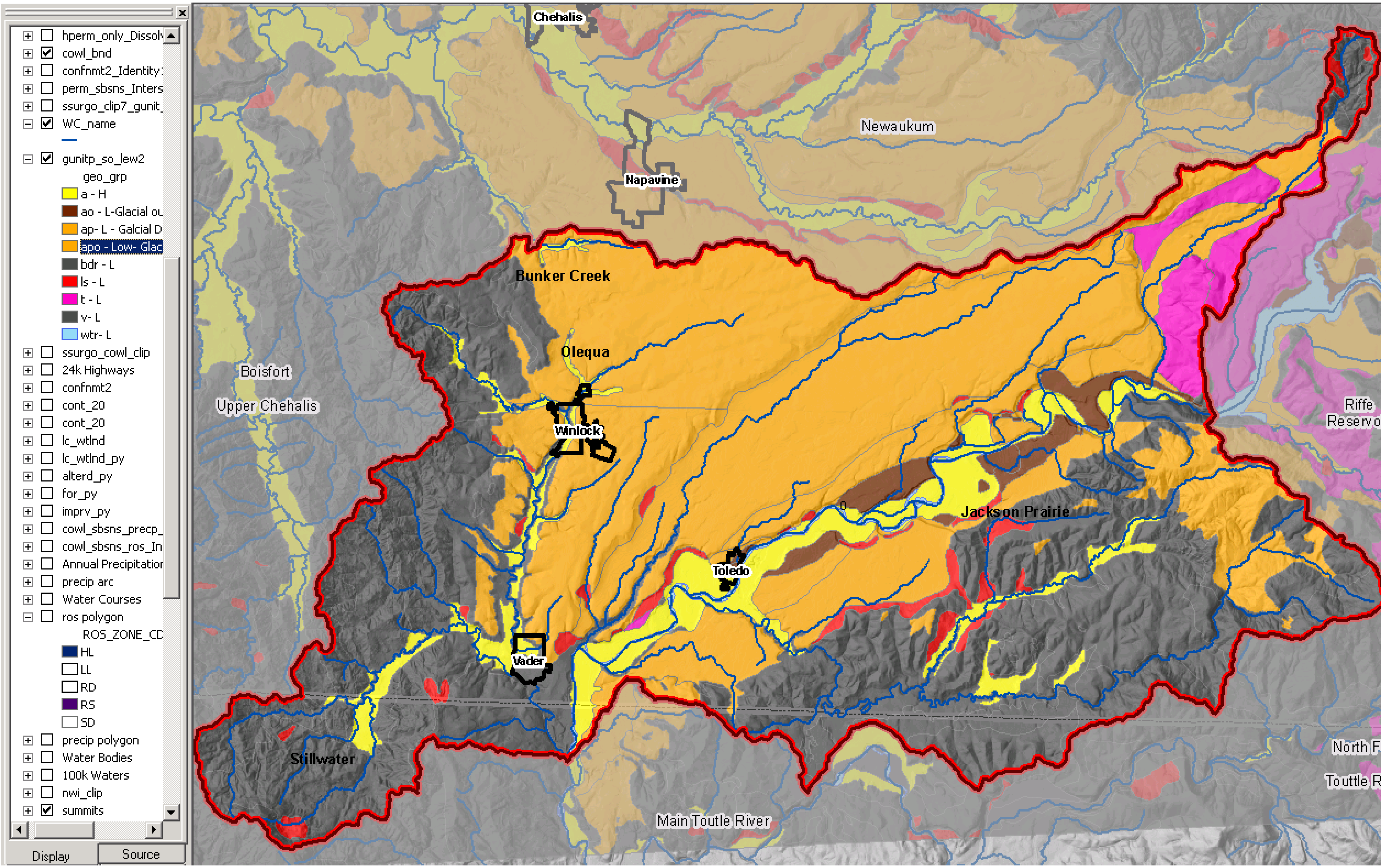


Figure C-7. Geology for South Lewis County. Yellow represents recent alluvial deposits for streams. Orange represents fluvial glacial deposits on intermediate terraces and plain terraces. Brown represents higher permeability outwash deposits. Red represents landslides. Pink represents glacial till deposits. Grey represents bedrock.

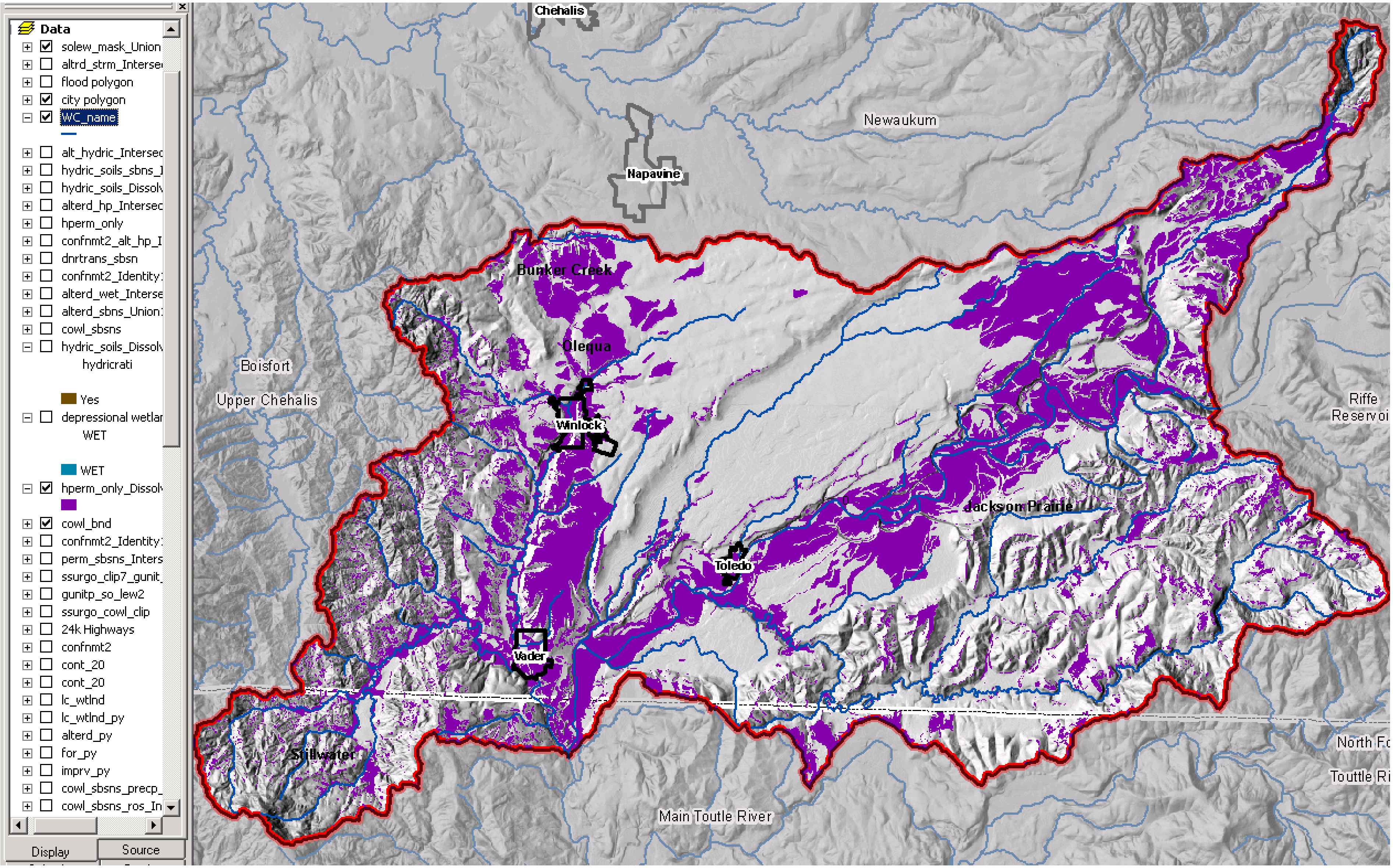


Figure C-8. Deposits With High Permeability. Purple represents the location of higher permeability deposits in South Lewis County.

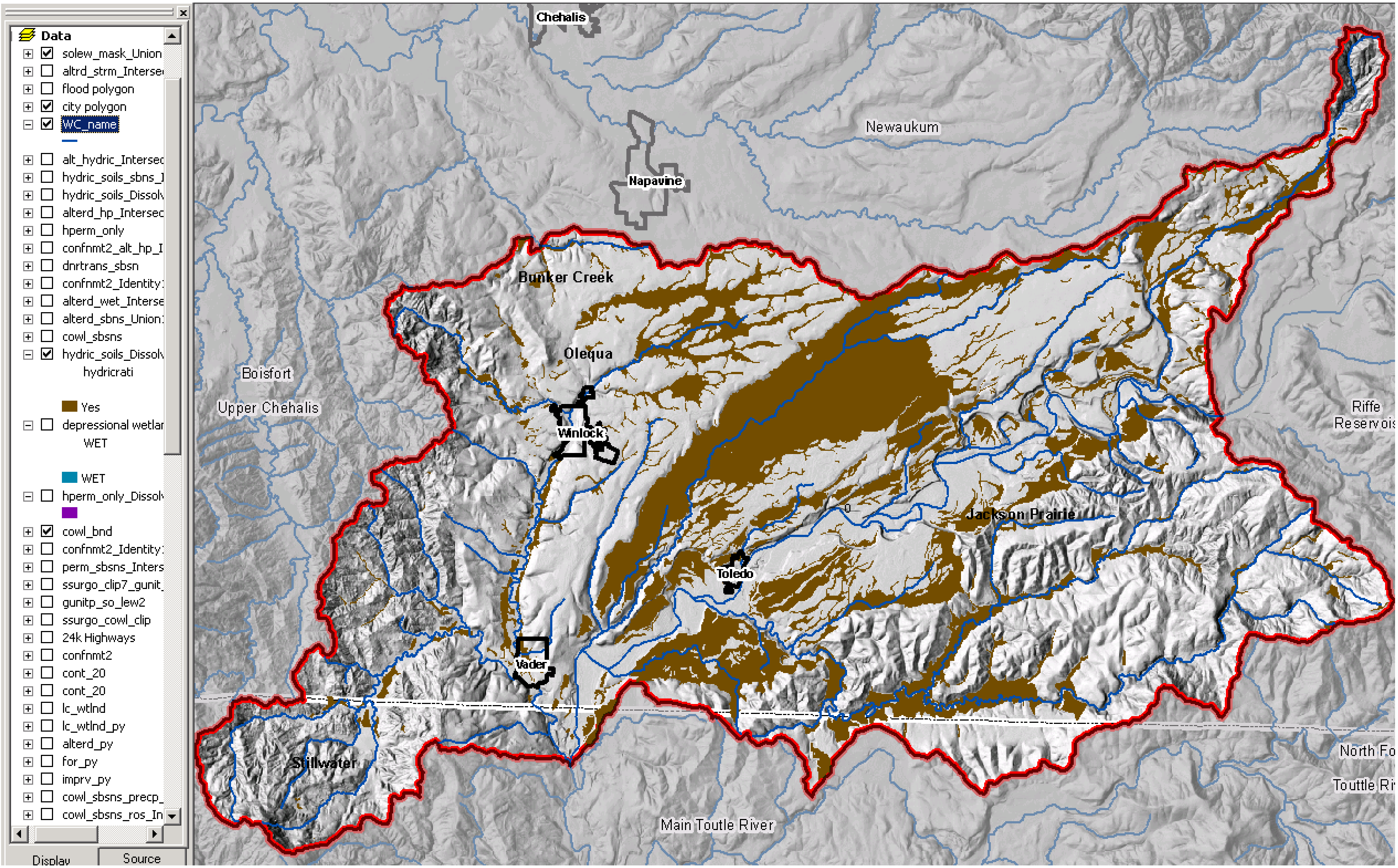


Figure C-9. Area of Hydric Soils in South Lewis County (brown).

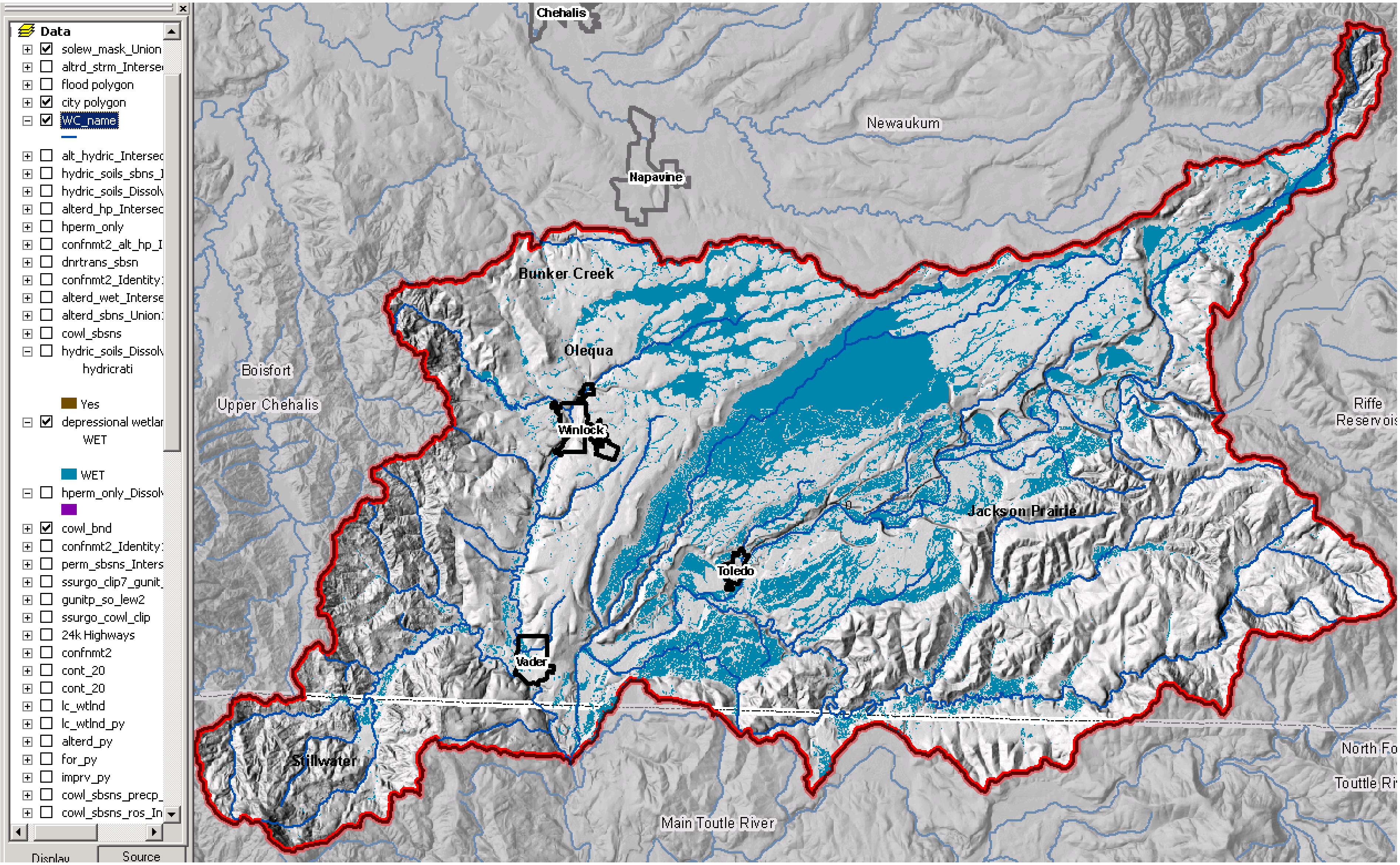


Figure C-10. Depressional Wetlands (includes both potential and existing wetlands)